Rahway River Basin, New Jersey
Flooood Risk Management Feasibility Study

APPENDIX A1
HABITAT SURVEY AND NJDEP WATER QUALITY MONITORING STATION LOCATIONS

Figure 1: Orange Reservoir Stream and Wetland USACE Habitat Survey and NJDEP Water Quality Monitoring Station Locations

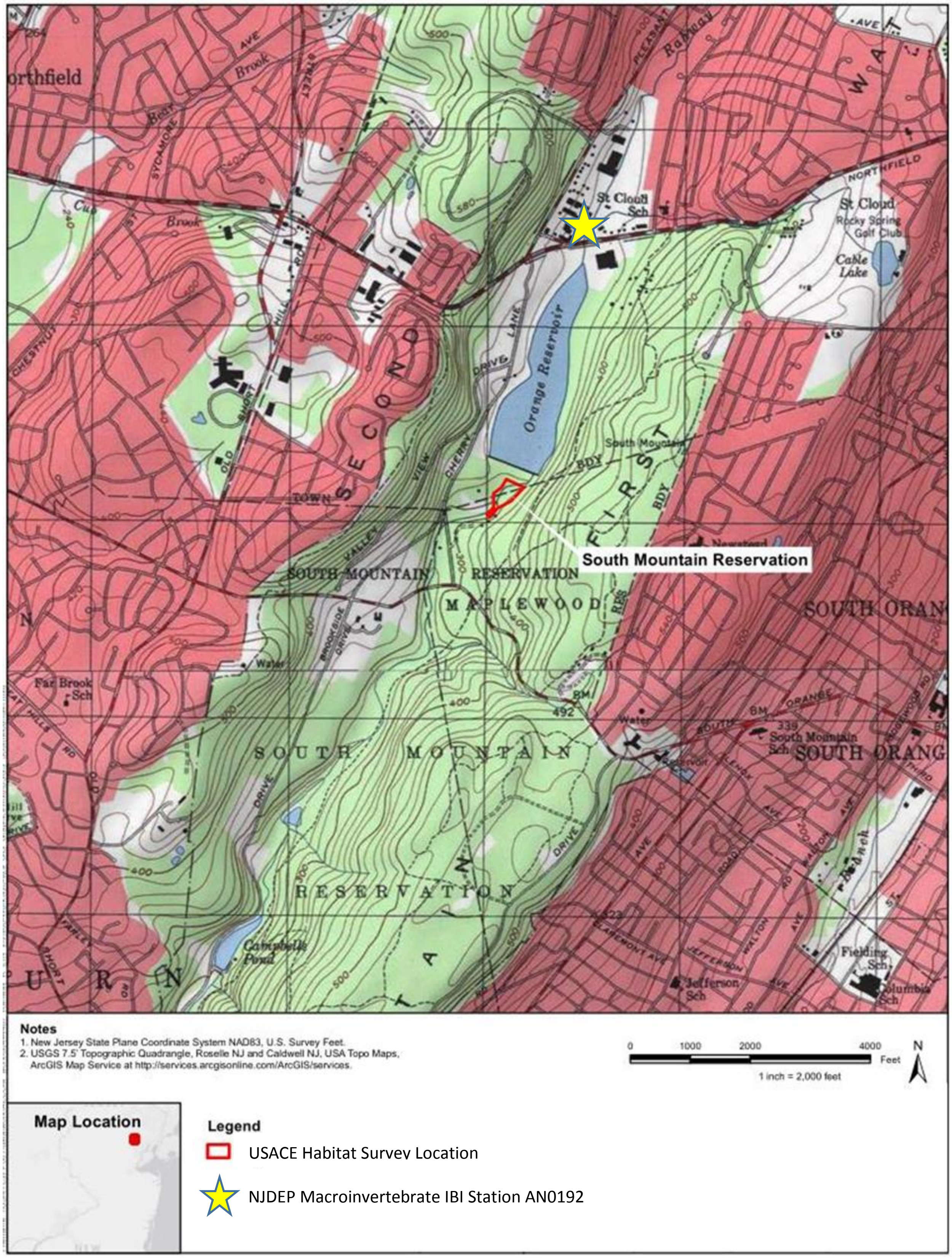


Figure 2: Township of Cranford USACE Stream and Wetland Habitat Survey and NJDEP Water Quality Monitoring Station Locations

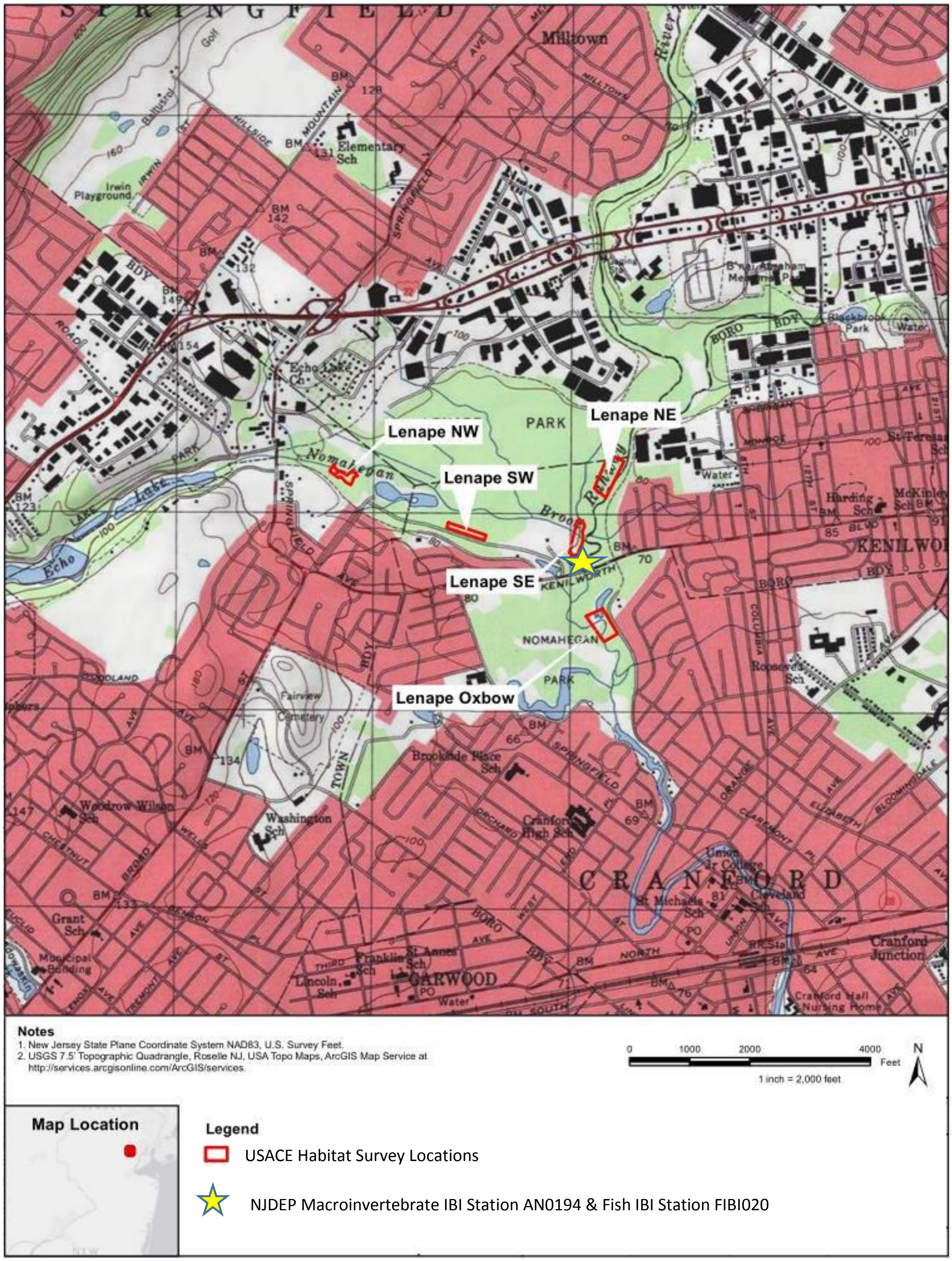
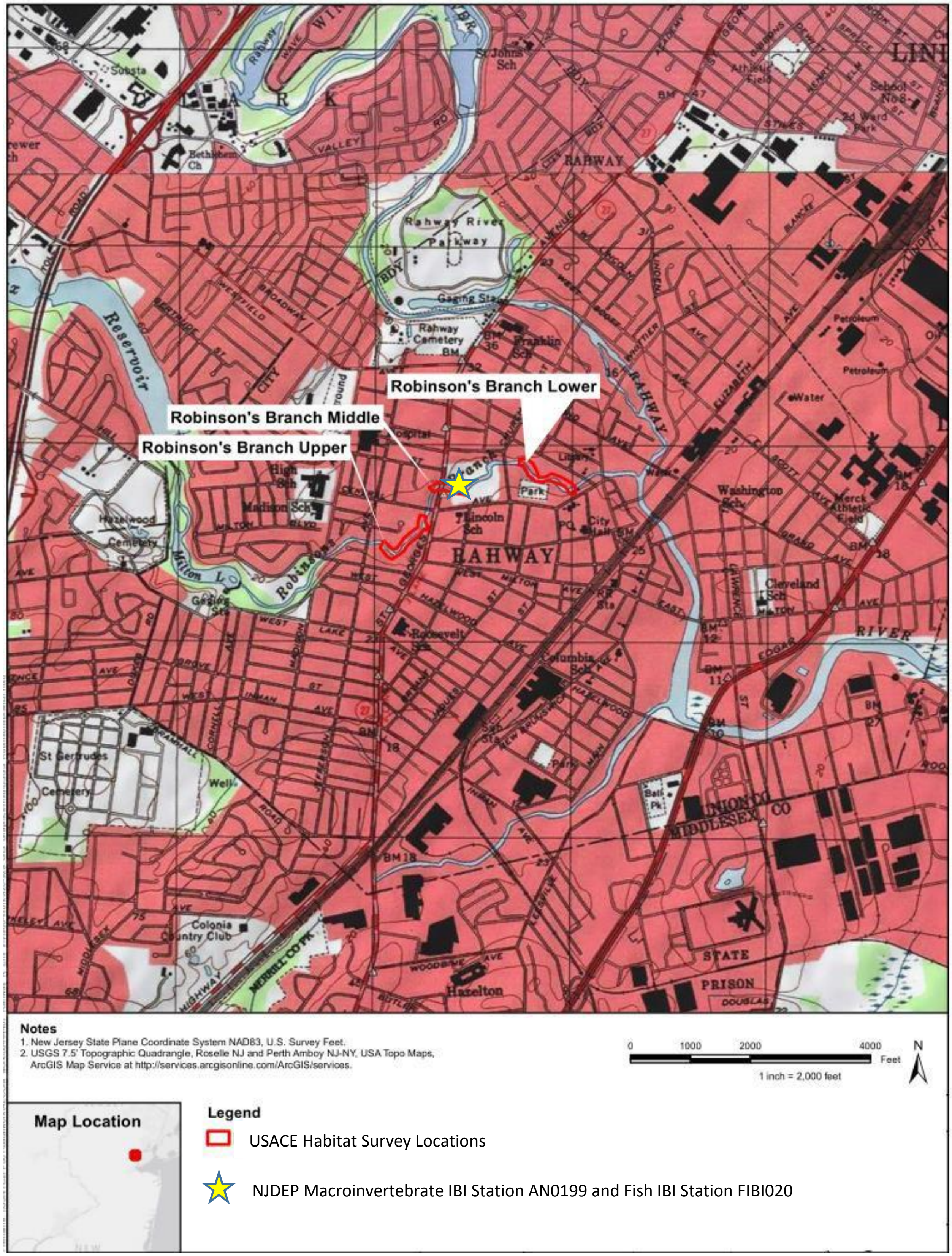


Figure 3: Robinson's Branch Stream and Wetland Habitat Survey and NJDEP Water Quality Monitoring Locations



Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

APPENDIX A2
Vegetation List

Rahway River Basin Flood Risk Management Study
Vegetation Observed During Field Investigations

Cover type	Common Name	Scientific Name	Lenape Park and Nomahegan Park					Robinson's Branch			South Mountain
			NW	SW	SE	NE	Oxbow	Upper	Middle	Lower	
T	American elm	*Ulmus Americana*	X	X	X						
T	Ash	*Fraxinus spp.*	X	X			X	X			
T	Basswood	*Tilia Americana*								X	
T	Beech	*Fagus grandifolia*									X
T	Black cherry	*Prunus serotina*		X			X				
T	Blackgum	*Nyssa sylvatica*			X						
T	Box elder	*Acer negundo*			X		X	X			
T	Catalpa	*Catalpa sp.*					X				
T	Eastern cottonwood	*Populus deltoides*		X	X						
T	Hickory	*Carya spp.*	X								X
T	Ironwood	*Carpinus caroliniana*						X			
T	Mulberry	*Morus spp.*						X			X
T	Norway maple (I)	*Acer platanoides*					X	X	X		
T	Oak	*Quercus spp.*						X	X	X	
T	Red maple	*Acer rubrum*	X	X	X					X	X
T	Pin oak	*Quercus palustris*		X	X		X			X	
T	Red oak	*Quercu srubra*						X			X
T	Silver maple	*Acer saccharinum*	X			X	X		X	X	
T	Sugar maple	*Acer saccharum*						X			X
T	Swamp White Oak	*Quercus bicolor*					X				
T	Sweetgum	*Liquidambar styraciflua*	X		X	X	X				
T	Sycamore	*Platanus occidentalis*	X	X	X	X	X	X			
T	Tulip tree	*Liriodendron tulipifera*			X						
T	Willow	*Salix spp.*					X				
S	Honeysuckle	*Lonicera sp.*					X				X
S	Arrowwood	*Viburnum dentatum*		X	X		X	X			X
S	Dogwood	*Cornus sp.*		X	X		X				
S	Holly	*Ilex sp.*			X						

Rahway River Basin Flood Risk Management Study
Vegetation Observed During Field Investigations

Cover type	Common Name	Scientific Name	Lenape Park and Nomahegan Park					Robinson's Branch			South Mountain
			NW	SW	SE	NE	Oxbow	Upper	Middle	Lower	
S	Multiflora rose (I)	*Rosa multiflora*		X	X						
S	Red osier dogwood	*Cornus stoloniferia*									X
S	Rubus	*Rubus spp.*					X				
S	Sumac	*Rhus typhina*							X		
S	Winged euonymus	*Euonymus sp.*									X
V	Grape	*Vitis spp.*	X			X	X	X	X		
V	Green Briar	*Smilax sp.*					X	X		X	
V	Japanese hops (I)	*Humulus japonicus*								X	
V	Nightshade	*Solanum dulcamara*	X					X			
V	Poison ivy	*Toxidendron radicans*	X	X	X	X		X	X		
V	Virginia creeper	*Parthenocissus quinquefolia*	X	X		X	X	X			
H	Arrow arum	*Peltandra virginica*		X							
H	Poa grass	*Poa spp.*					X	X		X	
H	Arrowleaf tearthumb	*Persicaria sagittata*			X		X				
H	Aster	*Asteraceae sp.*			X		X				
H	Cattails	*Typha spp.*			X		X				X
H	Chicory	*Cichorium intybus*			X						X
H	Cinnamon fern	*Osmundastrum cinnamomeum*		X			X				X
H	Clover	*Trifolium pratense*		X							X
H	Common reed	*Phragmites australis*		X							X
H	Creeping jenny	*Lysimachia nummularia*	X	X	X	X	X	X		X	X
H	Garlic mustard (I)	*Alliaria petiolata*	X	X	X	X	X	X		X	X
H	Goldenrod	*Solidago spp.*	X	X	X		X			X	
H	Deer Tongue	*Dicanthelium spp.*		X			X				
H	Dock	*Rumex spp.*					X				
H	Grass	*Gramineae*	X	X	X	X	X	X	X	X	X
H	Ground ivy	*Glechoma hederacea*	X	X	X	X					
H	Japanese knotweed (I)	*Fallopia japonica*	X	X	X	X	X			X	
H	Japanese spurge (I)	*Pachysandra terminalis*					X				
H	Japanese stiltgrass (I)	*Microstegium vimineum*			X		X				

Rahway River Basin Flood Risk Management Study
Vegetation Observed During Field Investigations

Cover type	Common Name	Scientific Name	Lenape Park and Nomahegan Park					Robinson's Branch			South Mountain
			NW	SW	SE	NE	Oxbow	Upper	Middle	Lower	
H	Jewelweed	*Impatiens capensis*	X				X		X	X	X
H	Lambs quarters	*Chenopodium album*	X					X			
H	Loosestrife	*Lythrum spp.*			X				X		
H	Mallow	*Althaea spp.*		X							
H	Milkweed	*Asclepias spp.*			X						
H	Moss	*Bryophyta*	X	X	X	X	X	X	X	X	X
H	Mugwort	*Artesemia vulgaris*							X	X	
H	Pennsylvania knotweed	*Polygonum pensylvanicum*	X	X	X	X	X	X	X		X
H	Pineapple weed	*Matricaria discoidea*						X			
H	Plantain	*Plantago spp.*						X			
H	Pokeweed	*Phytolacca americana*		X					X		
H	Purple loosestrife	*Lythrum salicaria*						X			
H	Queen Anne's lace	*Daucus carota*			X						
H	Reed canary grass	*Phalaris arundinacea*			X		X				X
H	Sedge	*Carex spp.*	X	X	X		X				X
H	Sedge	*Carex Lurida*					X				x
H	Sedge	*Carex Setaraia*		X			X				
H	Sensitive fern	*Onoclea sensibilis*		X							X
H	Skunk cabbage	*Symplocarpus foetidus*		X							
H	Soft rush	*Juncus effusus*		X	X		X				X
H	Stinging nettle	*Urtica dioica*			X		X				
H	Timothy	*Phleum pratense*		X							X
H	Violet	*Viola sp.*	X	X	X						X
H	Wild onion	*Allium canadense*			X						X
H	Woolgrass	*Scirpus cyperinus*		X			X				

Notes:
X = Observed on site.
T = Tree; S = Shrub; V = Vine; and H = Herbaceous I = Listed as an invasive species in NJ

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

APPENDIX A3
Section 404 (b)(1) Evaluation

Rahway River Flood Risk Management Feasibility Study, Union and Essex Counties, New Jersey

Section 404 (b)(1) Evaluation

I. Introduction

This 404(b)(1) summarizes the evaluation of effects the proposed action will have on water resources pursuant to the Clean Water Act Section 404(b)(1) guidelines. The proposed action involves the replacement and outlet modification of the Orange Reservoir, and channel modifications in the Township of Cranford. For a full description of the project, existing conditions and environmental impacts, refer to the draft Feasibility Report/Environmental Impact Statement (draft Feasibility Report/EIS). As indicated in the draft Feasibility Report/EIS, although a complete dam replacement may not be required, for the purposes of the environmental impacts, a full dam replacement including the complete drawdown of the Orange Reservoir is assessed in this 404(b)(1) Evaluation.

II. PROJECT DESCRIPTION

a. Location: West Orange, Essex County, and the Township of Cranford, Union County, New Jersey.

b. General Description: Replacement of Orange Reservoir dam and modification of outlets and modification of 8,390 linear feet of the Rahway River in the Township of Cranford. Replacement of the Orange Reservoir will require a complete drawdown during construction. A channel will be excavated within the reservoir to maintain flow of the Rahway River during construction.

c. Authority and Purpose: The study was authorized in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives. The Rahway River Basin resolution was dated 24 March 1998. The purpose of the project is to provide flood risk management to communities within the Rahway River watershed.

d. General Description of Fill Material:

1) Characteristics of Material: Material to be used for the Orange Reservoir dam replacement and outlet modification include embankment fill, stone/riprap and concrete. Material used for the construction of the channel modifications include rock/riprap, soil and steel sheet piling.

2) Quantity of Material: Approximately 108,950 cy of fill, 1,895 cy of concrete and 9,471 cy of rock/riprap will be used to replace the dam. Approximately 3,970 cy of riprap/rock and 100 linear feet of steel sheetpile for the channel modifications in the Township of Cranford. Approximately 21,000 cy of soil will be excavated to create the channel modifications.

3) Source of Material: The rock will be obtained from a local quarry. Embankment fill for the dam replacement will be obtained from an appropriate source

e. Description of the Proposed Discharge Sites

1) Location: The discharge site is located at the Orange Reservoir within the South Mountain Reservation in the City of West Orange, Essex County, and the segment of the Rahway River that flows through the Township of Cranford, Union Counties, New Jersey.

2) Size: The Orange Reservoir is approximately 700 acre feet and is 0.69 miles long and 0.50 miles wide. The dam is approximately 668 feet long. The length of the Rahway River

to undergo channel modifications in the Township of Cranford is approximately 8,390 linear feet.

3) Type of Site: The Orange Reservoir is a manmade reservoir used for recreational purposes located within the South Mountain Reservation in West Orange. The Rahway River is a freshwater system located within an urbanized setting comprised of predominantly residential structures in the Township of Cranford.

4) Types of Habitat: The Orange Reservoir is categorized as lacustrine with unconsolidated bottom. Habitat type within the vicinity of the Orange Reservoir includes upland deciduous forest and palustrine broad leaved deciduous forest. The aquatic habitat for both the Orange Reservoir and the Rahway River consists of non-tidal freshwater classified as FW2-NT by the NJDEP.

5) Time and Duration of Disposal: Construction of the Orange Reservoir dam replacement will take approximately 1.5 years. The pre-construction drawdown will occur in the September/October timeframe to minimize impacts to fish. Construction of the channel modifications in the Township of Cranford will take approximately six months. All in-water activities are restricted between 1 May and June 30 to comply with the NJDEP fish spawning window.

f. Description of Disposal Method: Land based construction equipment will be used to construct the project. The project will also be sequenced to minimize in water work to the extent possible.

III. FACTUAL DETERMINATION

a. Physical Substrate Determinations

1) Substrate Evaluation, Sediment Type and Slope: Sediment analyses have not been conducted for the Orange Reservoir. However, it is assumed that the sediments are comprised of finer silts, clays and/or sand material. The slope of the reservoir bottom is generally flat. The substrate of the Rahway River within the channel improvement footprint is composed of cobble/ gravel overlain with finer sediments such as silt and clay. The general slope of the channel cut will be approximately 2.35 ft./mile with a maximum deepening of about 1.9 ft. near the terminus of the channel improvement.

2) Dredged/Fill Material Movement: The excavation and placement of fill in the form of soil and riprap/stone will result in the impact of 8,390 linear feet of open water. Soil used to construct the channel will be stabilized with erosion control matting and vegetation.

3) Physical Effects on Stream Bottom: Excavation and fill activities associated with the channel modifications in the Township of Cranford could initially change the river substrate depending on the type of substrate exposed during construction.

4) Other Effects: N/A

5) Actions Taken to Minimize Impacts: Measures to be implemented to minimize adverse impacts to substrate include: a) implementation of erosion and sediment control best management practices; and b) restore the existing substrate within the channel modifications.

b. Water Circulation, Fluctuation and Salinity Determinations

1) Water, Consider Effects on:

(a) Salinity: No effect

(b) Water Chemistry: There may be minor changes to water chemistry as a result of suspended sediment during construction. Long term changes to water chemistry is not expected.
(c) Clarity: Water clarity may be slightly to moderately impacted during drawdown of the Orange Reservoir and through the construction of the channel modifications in the Township of Cranford. No long-term effect is anticipated.
(d) Color: Minor impacts associated with turbidity may affect water color during construction. Erosion and sediment control best management practices including the installation of cofferdams to construct the channel modifications will be implemented during construction to minimize turbidity.
(e) Odor: The sediment on the bottom of the Orange Reservoir may emit a foul odor as it dries out subsequent of the drawdown to complete the dam replacement. This is expected to be temporary and will be minimized through seeding the reservoir floor.
(f) Taste: The Rahway River is used as water supply for the City of Rahway. However, the water is withdrawn for treatment approximately three miles downstream of the Cranford portion of the project area and is treated prior to distribution to consumers. Therefore, the proposed action is not expected to have an adverse impact on taste.
(g) Dissolved Gas Levels: Dissolved oxygen levels may be reduced to some degree during construction, but this will be a temporary effect. The installation of erosion and sediment controls and stabilization of soil through grass seed, shrubs and tress will reduce sedimentation and pollutant runoff which can have detrimental impacts to dissolved oxygen levels.
(h) Nutrients: Nutrient load to the Rahway River may increase during construction as a result of resuspension of sediments during the pre-construction drawdown of the Orange Reservoir and the construction of channel modifications in the Township of Cranford. Erosion and sediment control best management practices will be implemented during construction to minimize the suspension of nutrient laden sediment during construction. The bottom and side slopes of the Orange Reservoir will be seeded with grass to prevent the suspension of sediment during storm events.
(i) Eutrophication: Eutrophication may occur within the channel constructed in the Orange Reservoir to maintain flow of the river through the reservoir during construction due to exposure to sun and nutrient laden sediments within the reservoir. Measures that will be implemented to minimize potential eutrophication include seeding the bottom of the reservoir
(j) Others as Appropriate: No other adverse impacts are anticipated from the project.

2) Current Patterns and Circulation:

(a) Current Patterns and Flow: There will be no significant adverse impacts to river current patterns or flow from implementation of the proposed action. Flow of the Rahway River will be maintained through the Orange Reservoir during dam replacement construction. Discharge rates from the reservoir during pre-construction drawdown will be at the same rate as existing conditions. Regarding the channel modifications in the Township of Cranford, baseflow conditions are anticipated to be similar to the pre-project conditions.
(b) Velocity: The installation of larger outlet pipes in the Orange Reservoir dam will increase discharge rates during pre-storm drawdown as compared to the existing velocities. However, this change is not considered significant. The channel modifications in the Township of Cranford will not substantially change velocities compared to existing conditions.
(c) Stratification: The project will not impact stratification.
(d) Hydrologic Regime: The proposed action will not change normal daily or seasonal water level fluctuations. However, the Orange Reservoir will be drawndown prior to storm

events to minimize flood risk. This is a temporary change since the reservoir will refill after the storm event. Refill times range from 30 hours for a 25-yr storm event versus 2 weeks should the storm not occur.

3) Normal Water Level Fluctuations: The project will not have any permanent adverse impacts on normal water level fluctuations. Subsequent of project completion, the Orange Reservoir will be partially drawndown from elevation 330 ft to elevation 315 ft prior to storm events. Depending on the storm event, the reservoir will refill within 30 hrs (for 25-yr storm event) to 2 weeks (if storm event does not occur).

4) Salinity Gradients: Not applicable

5) Actions Taken to Minimize Impacts: Measures to be implemented to minimize adverse impacts include: a) drawing down the Orange Reservoir at a slow rate and b) designing the channel modifications in the Township of Cranford to maintain the same velocities as existing conditions.

c. Suspended Particulate/Turbidity Determinations.

1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Sites: Minor increases in particle suspension and turbidity during the Orange Reservoir drawdown and construction of channel modifications in the Township of Cranford are expected to occur.

2) Effects on Chemical/Physical Properties of the Water Column:

(a) Light Penetration: Minor adverse impacts may occur within the project area during construction of the channel modifications due to turbid conditions.

(b) Dissolved Oxygen: Dissolved oxygen levels may be reduced during construction, particularly within the channel that will be constructed in the Orange Reservoir to maintain flow of the river through the reservoir during dam replacement. In order to minimize this potential, the grass that will be planted on the bottom of the reservoir will be allowed to grow to provide some shade.

(c) Toxic Metals and Organics: There is a slight potential that construction activities may disturb sediments contaminated with organics. Erosion and sediment controls such as silt fence and cofferdams to construct the channel modifications in the Township of Cranford will be implemented during construction to minimize the risk.

(d) Pathogens: There is a potential that the sediments within the Orange Reservoir could contain pathogens such as e. coli that could be transported during the drawdown and then through exposure of the sediments once the reservoir is drawndown. This potential will be minimized by performing the drawdown slowly to minimize sediment resuspension and through stabilization of the reservoir bottom with grass seed. In addition, exposure of the sediments to sunlight typically kills any waterborne pathogens.

(e) Aesthetics: The aesthetics of the Orange Reservoir will be adversely impacted during construction activities given that it will be completely drawndown. In addition, minor adverse impacts to aesthetics will occur during the drawdown prior to storm events. However, the reservoir will return to normal conditions within 30 hours to 2 weeks depending on the storm event. Aesthetics of the footprint of the channel modifications in the Township of Cranford will be impacted during construction and after construction. Actions that will be taken to minimize impacts of the channel modification include replacing material excavated for the channel and using rock from local sources to match existing rock material in the channel. Herbaceous vegetation will be planted along the riverbanks and trees and shrubs will be planted along the top of bank. Aesthetics will gradually improve as the vegetation that has been planted as part of the project matures.

(f) Others as Appropriate: Not applicable

3) Effects on Biota:

(a) Primary Production, Photosynthesis: Removal of mature trees reduces amount of organic material into the river that aquatic species use for food/cover/spawning.

(b) Suspension/ Filter Feeders: No permanent adverse impact is expected. Erosion and sediment control best management practices will be implemented during construction to reduce sedimentation to the Rahway River that could temporarily impact suspension/filter feeders.

(c) Sight Feeders: There may be temporary adverse impacts to sight feeders during the drawdown of the reservoir to complete the dam replacement and the construction of the channel modifications in theTownship of Cranford. These impacts will be minimized by performing the preconstruction drawdown slowly and through implementation of erosion and sediment control practices during construction.

4) Actions Taken to Minimize Impacts: Measures to be implemented to minimize adverse impacts include: a) implementation of erosion and sediment control best management practices; b) seeding the bottom and side slopes of the Orange Reservoir during the dam replacement; c) installation of cofferdams to construct the channel modifications in Township of Cranford; d) incorporating in-stream mitigation measures within the channel improvement; and e) replanting the river banks and top of bank with native vegetation.

d. Contaminant Determinations: There are no issues with contaminant issues within the study area. All fill material will be clean and will not pose a risk.

e. Aquatic Ecosystem and Organism Determinations.

1) Effects on Plankton: An increase in sedimentation/nutrients during construction may increase some plankton species such as algae. Erosion and sediment control best management practices will be implemented to reduce this potential. The channel modifications proposed in the Township of Cranford will be designed in a manner to maintain velocities in order to prevent algal blooms.

2) Effects on Benthos: Project construction will result in the removal of benthic species during channel creation. However, this impact is expected to be temporary as recruitment of benthic species from upstream areas is expected to occur subsequent of construction. The project will be designed in a manner to provide similar or better habitat than existing conditions in order to provide long term benefits to benthic species.

3) Effects on Nekton: Mobile aquatic life will move from area during construction.

4) Effects on Aquatic Food Web: The project will have temporary adverse impacts on the food web as a result of turbidity, draining of the reservoir during construction and channel modifications. Permanent significant adverse impacts are not expected from implementation of the project.

5) Effects on Special Aquatic Sites:

(a) Sanctuaries and Refuges: Not applicable

(b) Wetlands - Based on cursory field investigations, approximately 0.13 acres of forested wetlands will be permanently impacted through tree removal as part of compliance with the Corps policy of maintaining a 50 ft vegetation free zone from the toe of the dam. The specific mitigation type will be evaluated during the Preconstruction Engineering and Design Phase and will consist of either: a) wetland enhancement; b) wetland creation/restoration; or c) purchasing a wetland mitigation credit from a New Jersey Department of Environmental Protection approved wetland mitigation bank.

(c) Mudflats: Not applicable

(d) Vegetated Shallows: Not applicable

(e) Coral Reefs: Not applicable

(f) Riffle and Pool Complexes: Any existing pool and riffle complexes within the footprint of the channel modifications in theTownship of Cranford will be removed during construction. However, pool and riffle complexes will be incorporated into the design of the improved channel and should also re-establish through natural morphological process once construction is completed.

6) Threatened and Endangered Species: The proposed action may remove potential summer roosting habitat for the federally and state endangered Indiana bat and federally threatened northern long-eared bat. A tree clearing restriction from 1 April through 30 September will be implemented during construction to protect these species. Multiple endangered, threatened, and special concern bird species have been documented in the project area. A shrub and tree clearing restriction from 15 March through 31 July will be implemented to comply with the Migratory Bird Treaty Act will protect these species. In addition, native vegetation will be replanted on-site of the channel modifications as well as off-site to compensate for the removal of vegetation associated with the dam replacement and channel modifications.

7) Other Wildlife: The project will mainly have temporary adverse impacts to wildlife. Minor adverse temporal impacts to wildlife will occur as a result of the removal of mature vegetation that is used for nesting, shelter and foraging. These impacts will be minimized through replanting of vegetation and the use of larger tree stock as opposed to saplings in the replanting efforts.

8) Actions to Minimize Impacts: Measures to be implemented to minimize adverse impacts include: a) implementation of erosion and sediment control best management practices; b) seeding the bottom and side slopes of the Orange Reservoir during the dam replacement; c) installation of cofferdams to construct the channel modifications in the Township of Cranford; c) adhering to woody vegetation clearing windows from 15 March through 30 September to protect federal endangered and threatened bat species as well as migratory bird species; d) incorporating in-stream mitigation measures within the channel improvement; and e)replanting the river banks and top of bank with native vegetation.

f. Proposed Disposal Site Determinations

1) Mixing Zone: Not applicable

2) Determination of Compliance with Applicable Water Quality Standards: All fill used to construct the project will be comprised of clean material that meets water quality standards.

3) Potential Effects on Human Use Characteristic:

(a) Municipal and Private Water Supply: The Rahway River is used as a water supply for the City of Rahway. The location of the treatment plant is located approximately three miles downstream of the proposed channel modifications in the Township of Cranford. Since the water is treated prior to distribution, no adverse impacts are expected.

(b) Recreational and Commercial Fisheries: Although not specifically stocked, the Orange Reservoir is used for fishing and has held annual fishing derbies since 2014. Fishing activities within the Orange Reservoir during construction and during any pre-storm drawdown will be adversely impacted. The impacts associated with the construction drawdown will be semi-permanent given that the reservoir will be drawndown for 1.5 yrs. The pre-storm drawdown will be temporary as the reservoir is expected to refill between 30 hours to 2 weeks depending on the storm event.

The Rahway River within the footprint of the channel improvement in the Township of Cranford is used as a recreational fishery and is stocked with trout by the New Jersey Division of Fish and Wildlife. One of the locations where the NJDFW stocks is located within the footprint of the channel modifications in Tthe ownship of Cranford. It is expected that the New Jersey Division of Fish and Wildlife will suspend stocking in this location until construction is completed. The channel modifications may have moderate temporal impacts on recreational fishing until the river system recovers.

(c) Water Related Recreation: The Orange Reservoir supports water dependent activities such as paddle boating and fishing. These activities will be suspended during the drawdown to complete the dam replacement as well as during pre-storm drawdown. Water dependent activities supported by the Rahway River in the Township of Cranford include kayaking, canoeing and fishing. These activities will be suspended during construction of the channel modifications but can resume once construction is completed.

(d) Aesthetics: The aesthetics of the Orange Reservoir will be adversely impacted during construction due to the drawdown of the reservoir. The bottom and side slopes of the reservoir will be seeded to minimize adverse aesthetic impacts. Significant adverse impacts to aesthetics of the reservoir during pre-storm drawdown are not expected.

The river within the channel improvement footprint in the Township of Cranford may have an initial “engineered” appearance; however, as the vegetation matures and the river substrate returns through its natural aggradation/degradation processes, the aesthetics will improve and develop a more natural look.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves:

The Orange Reservoir is part of the South Mountain Reservation, an Essex County owned park. During construction, use of the Orange Reservoir by park patrons will be limited. There will be no adverse impacts to the use of the larger South Mountain Reservation.

There are seven parks adjacent to the portion of the Rahway River in the Township of Cranford that are located within the channel improvement project area. There may be temporary park closures during construction due to the actual construction of the project and the possibility of using the parks as staging areas. Permanent adverse impacts to park use as a result of implementation of the proposed action is not expected.

g. Determination of Cumulative Effects on the Aquatic Ecosystem: The proposed action will have negligible cumulative impacts on the aquatic ecosystem. Mitigation measures proposed in the above sections will minimize cumulative impacts.

h. Determination of Secondary Effects on the Aquatic Ecosystem: No secondary effects on the aquatic ecosystem are expected from this project.

IV. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE.

a. No significant adaptation of the Section 404(b)(1) guidelines was made relative to this evaluation.

b. The objective of flood risk management necessitates the replacement of the Orange Reservoir and the modification of 8,390 ft of the Rahway River.

c. The proposed activity will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The proposed disposal operations will not harm any endangered species or their critical habitats under the Endangered Species Act of 1973.

e. The proposed discharge of fill material will not result in significant adverse effects on human health and welfare, including municipal and private waters supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and other wildlife will not be significantly affected.

f. Appropriate steps to minimize potential adverse impacts of the discharge of fill material include the implementation of an erosion and sediment control plan and judicious engineering practices.

Rahway River, New Jersey

Flood Risk Management Feasibility Study

APPENDIX A4 USFWS

Correspondence

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, N.Y. 10278-0090

REPLY TO
ATTENTION OF
Environmental Analysis Branch

22 September 2016

Mr. Eric Schrading
Field Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Unit 4
Galloway, New Jersey 08205-4465

Dear Mr. Schrading:

The Army Corps of Engineers, New York District (District) is conducting a feasibility study to implement flood risk management measures along the Rahway River in Cranford and Millburn Townships, Essex and Union Counties and the Robinson's Branch in the City of Rahway, Union County, New Jersey. The Scope of Work for your office to prepare a Draft and Final Fish and Wildlife Coordination Act Report (FWCAR) was negotiated on 18 April 2016 (Enclosure 1) with the acceptance of a revised Government Order being transmitted to the District on 6 September 2016.

The Tentatively Selected Plan (TSP) has been identified and involves the modification of the Orange Reservoir in Essex County, channel improvements to the Rahway River in Cranford Township and nonstructural measures in the City of Rahway. Per email coordination between Ms. Kimberly Rightler and Mr. Ron Popowski on 12 September 2016, due to staffing constraints, the preparation of the Draft FWCAR is expected to begin around the end of October. The District is currently scheduled to release the integrated draft Feasibility Report/Environmental Impact Statement for public review around the same time. Therefore, the District will provide you with a copy of the draft report to serve as the basis for the Draft FWCAR.

In the interim, enclosed are several attachments that describe the Tentatively Selected Plan (Enclosure 2), summarize key environmental impacts and mitigation measures (Enclosure 3), and figures indicating the locations New Jersey and USFWS National Wetland Inventory mapped wetlands (Enclosures 4 and 5). The District welcomes any initial feedback regarding the effects the TSP may have on fish and wildlife resources, including federally endangered and threatened species, along with any initial recommendations on how to minimize adverse effects to these resources.

The District will continue to coordinate with your agency closely to assist in your preparation of the report. Should any questions arise, or additional information is needed, please contact Ms. Kimberly Rightler at (917) 790-8722.

Sincerely,

Peter Weppler
Chief, Environmental Analysis Branch

Enclosures

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
4 E. Jimmie Leeds Road, Suite 4
Galloway, New Jersey 08205
Tel: 609-646-9310 Fax: 609-646-0352
http://www.fws.gov/northeast/njfieldoffice

IN REPLY REFER TO:
16-CPA-0125

Nancy Brighton, Section Chief
Environmental Analysis Branch
New York District, U.S. Army Corps of Engineers
Jacob K. Javits Federal Building
26 Federal Plaza
New York, New York 10278-0090
Attn: Kimberly Rightler

APR 18 2016

Dear Ms. Brighton:

This letter responds to your March 7, 2016 request to the U.S. Fish and Wildlife Service (Service) to provide a Fiscal Year 2016 (FY2016) scope of work (SOW) for services pursuant to the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401; 16 U.S.C. 661 *et seq.*) regarding the U.S. Army Corps of Engineers, New York District's Rahway River Flood Risk Management Feasibility Study, Millburn Township, Essex County; Cranford Township and City of Rahway, Union County, New Jersey.

Enclosed please find a draft FY2016 SOW including the Service's staff time and cost for services, estimated at $16,492. The Service will provide draft and final FWCA 2(b) reports pursuant to Section 2(b) of the FWCA. The reports will contain updated information regarding wildlife resources and an assessment of impacts and benefits to these resources from the proposed project.

If you are in agreement with the draft SOW and the estimated cost for services, please prepare the appropriate transfer funding agreement and send via e-mail to Laura_Perlick@fws.gov.

The Service looks forward to working cooperatively with you and your staff to assess and minimize wildlife impacts from the project. If you have any questions regarding the cost estimate or any other aspect of this SOW, please contact Ron Popowski by email at Ron_Popowski@fws.gov.

Sincerely,

Eric Schrading
Field Supervisor

Enclosure

Fiscal Year 2016 Draft Scope of Work
U.S. Fish and Wildlife Service / U.S. Army Corps of Engineers
Rahway River Flood Risk Management Study
Millburn Township, Essex County,
Cranford Township and City of Rahway, Union County, New Jersey

I. SUBJECT:

The scope of work (SOW) between the U.S. Fish and Wildlife Service (Service)'s New Jersey Field Office (Service) and the U.S. Army Corps of Engineers, New York District (Corps) to prepare a draft and final 2(b) reports pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401; 16 U.S.C. *et seq.*) for the Corps' Rahway River Flood Risk Management Feasibility Study (FRM), Millburn Township, Essex County; Cranford Township and City of Rahway, Union County, New Jersey (Study Area). Transfer funding from the Corps to the Service is authorized pursuant to the Economy Act (96 Stat. 933; 31 U.S.C. 1535).

Agency Financial Information

Service:
DUNS: 151157950
Tax ID: 53-0201504
Agency Locator Code: 14160006

Corps:
DUNS: 068112791
Tax ID: 62-1642142
Agency Locator Code: 00008736
Business Event Type Code: DISB
Treasury Account Symbol: To be determined

If the Corps cancels the agreement, the Service may collect costs incurred prior to the cancellation of the agreement plus any termination costs.

II. PROJECT NAME:

Rahway River Flood Risk Management Feasibility Study (FRM)

III. CORPS DISTRICT AND CONTACTS:

U.S. Army Corps of Engineers New York District,
26 Federal Plaza
New York, New York, 10278-0090

Chief, Watershed Section:	Nancy Brighton	Nancy.Brighton@usace.army.mil
Project Biologist:	Kimberly Rightler	Kimberly.A.Rightler@usace.army.mil
Financial Point of Contact:	Rifat Salim	Rifat.Salim@usace.army.mil

IV. SERVICE OFFICE AND CONTACTS:

U.S. Fish and Wildlife Service
New Jersey Field Office
Ecological Services
4 E. Jimmie Leeds Road, Suite 4
Galloway, New Jersey 08205

Field Supervisor	Eric Schrading	Eric_Schrading@fws.gov
Project Biologist	Dennis Hamlin	Dennis_Hamlin@fws.gov
Financial Point of Contact	Laura Perlick	Laura_Perlick@fws.gov

V. DESCRIPTION OF PROJECT:

The Feasibility Study involves formulating and evaluating the feasibility of implementing flood risk management measures within the 500-yr floodplain of the portion of the Rahway River located in the Towns of Millburn and Cranford (Cranford Component) in Essex and Union counties and the Robinson's Branch in the City of Rahway (Robinson's Branch Component) in Union County, NJ.

Alternatives being evaluated include No Action and Non-Structural for both the Cranford and Robinson's Branch Component. In addition, structural flood risk management measures that will be evaluated for the Cranford Component may consist of modification of the Orange Reservoir, modification of the Lenape Park dam and embankment's, and channel modifications. Structural flood risk management measures that will be evaluated for the Robinson's Branch may consist of channel modification and levees/floodwalls.

VI. STATUS OF STUDY:

The Corps is conducting a feasibility study to evaluate Federal participation in FRM in the Rahway River Basin, New Jersey as authorized by the U.S. House of Representatives Resolution Docket 2548, dated March 24, 1998.

Flooding within the Rahway River Basin is caused principally by the rapid development of the area, which has resulted in a large increase of storm water runoff. Floods have caused damage to houses, businesses, municipal facilities and public infrastructure.

The Corps is currently evaluating FRM alternatives to determine the Tentatively Selected Plan (TSP). Identification of a TSP is anticipated to occur in May/June 2016 with the Draft Integrated Feasibility Report and Environmental Impact Statement being issued for public/agency review in August 2016.

The Service prepared a Planning Aid Letter dated February 20, 2015 to provide recommendations on preliminary alternatives in support of the Feasibility Study. The FWCA report to be prepared under this SOW is required to comply with the Fish and Wildlife Coordination Act and will focus on providing recommendations for the TSP.

VII. COORDINATING AND SCOPING:

The Corps and the Service will coordinate routinely as necessary.

VIII. DATA AND INFORMATION NEEDED FROM THE CORPS:

1. Signed SOW

2. Completed and signed transfer funding agreement via Military Interdepartmental Purchase Request (MIPR).

IX. SPECIFIC WORK TO BE ACCOMPLISHED BY THE SERVICE:

1. Review the conceptual plan of the TSP and any other supplemental information provided by the Corps.

2. Provide Corps with information on fish and wildlife resources (including endangered and threatened species) in the Study Area.

3. Conduct a site visit.

4. Coordinate with the Corps and the New Jersey Department of Environmental Protection (NJDEP), including New Jersey Division of Fish and Wildlife (NJDFW), and other agencies/organizations regarding project area resources, project related impacts, and means and measures that should be adopted to prevent the loss of or damage to fish and wildlife resources, as well as to provide for the development and improvement of such resources.

5. Conduct a technical review of the preliminary alternatives that have been developed to date to evaluate impacts of the alternatives on fish and wildlife resources.

6. For any alternatives proposed by the Service that deviate significantly from the proposed plan or include experimental techniques, the Service shall provide a discussion of benefits gained by the proposed alternative, along with case studies, photographs and/or typical details in order to assist the Corps in considering incorporation of the alternative into the overall alternative evaluation process.

7. Provide a draft FWCA 2(b) report addressing the overall potential impacts to fish and wildlife resources from the FRM project, including recommended measures that should be adopted to prevent the loss or damage to those resources.

8. Provide a final FWCA 2(b) reports addressing and incorporating comments received from Corps, NJDEP, and NJDFW on the draft FWCA 2(b) report.

X. CORPS INPUT TO SERVICE:

The Corps will provide project documents and technical information developed during the course of study, secure and provides other existing Corps documents that the Service may request, and coordinate routinely as project plans are refined.

The Corps will provide comments or concurrence with the Service's written products within 30 days of submission. Once any comments are addressed and the Corps provides concurrence, Service products will become public documents available to outside parties upon request.

XI. SERVICE INPUT TO CORPS:

Service submits Draft FWCA 2(b) report	September 30, 2016
Service submits Final FWCA 2(b) report	January 30, 2017

XII. CORPS AND SERVICE SUBMISSION SCHEDULE:

	Target Date
Corps provides current plans, documents and information; and transmits funding.	Within 7 days after receipt of MIPR.
Service submits draft FWCA 2(b) report to the Corps, NJDEP and NJDFW.	Within 60 days after receipt of project plans.
Corps, NJDEP and NJDFW provide comments on draft FWCA 2(b) report.	Within 15 days after receipt of draft FWCA 2(b) report
Service addresses Corps, NJDEP, and NJDFW comments and submits final FWCA 2(b) report.	Within 20 days after receipt of Corps, NJDEP, and NJDFW comments.

XIII. SERVICE EFFORTS AND COSTS

Service Effort	**Task Days**
Investigate fish and wildlife resources within the vicinity of the project area, including review of available literature and coordination with the NJDEP and NJDFW	**4**
Conduct a site visit	**1**
Provide section 7 consultation pursuant to the Endangered Species Act (87 Stat.884; 15 U.S.C. 1551 et seq.) (not charged to project transfer funds)	—
Conduct technical review of the preliminary alternatives that have been developed to date	**6**
Prepare draft FWCA 2(b) report	**6**
Prepare final FWCA 2(b) report	**2**

Total Service Task Days	**19***
***Biologist Day Rate ($629) x Overhead Rate (38% or $239)**	**$868**
19 Service Task Days x $868	**$16,492**
Total:	**$16,492**

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study
Tentatively Selected Plan

U.S. Army Corps of Engineers
New York District

Photo By The Cranford Chronicle

New Jersey
Department of Environmental Protection
Non-Federal Sponsor

U.S.ARMY

US Army Corps of Engineers
BUILDING STRONG®

Rahway River Basin Flood Risk Management Study
Tentatively Selected Plan

- Install 2 new 36" outlet pipes, possible replacement in-kind* of Orange Reservoir.

  *Replacement in-kind of Orange Reservoir is a worst case scenario. Investigations and analysis during design phase may indicate rehabilitation, not replacement. Cost estimate assumes complete draining of reservoir for replacement during construction.
- Approximately 8,930 ft. of trapezoidal channel improvements (35-45 ft. width) along the Rahway River (end of Nomahegan Park to South Ave.) in Cranford Township.

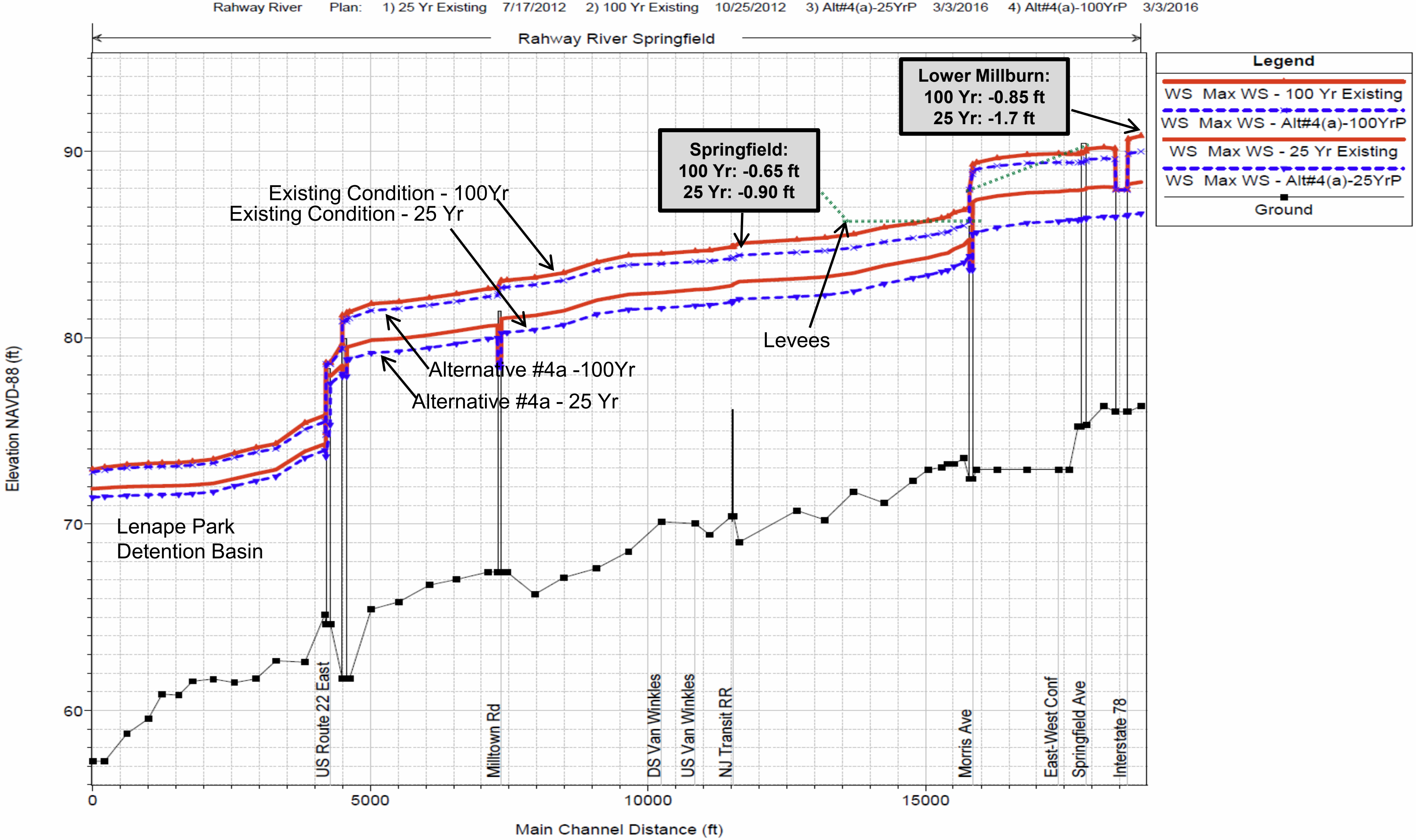
- This alternative is likely to contain less than the 4% chance of annual exceedance flood in Cranford Township (25 Yr.).
  - Better use of the flow detention capacity of Orange Reservoir will mitigate the increase in downstream flow caused by deepening and widening the channel.
- 21 structures in City of Rahway to receive nonstructural treatments
  - Measures examined will include dry and wet floodproofing, ring walls, elevation and buyouts.

Nonstructural Flood Proofing Measure	10% (10-yr) Annual Exceedance		
	Residential	Non-Residential	Sub Total
Dry Flood proofing	0	0	0
Wet Flood proofing	1	1	2
Ringwalls/Levees	2	4	6
Raise	13	0	13
Buyout	0	0	0
Total of Structures	16	5	21

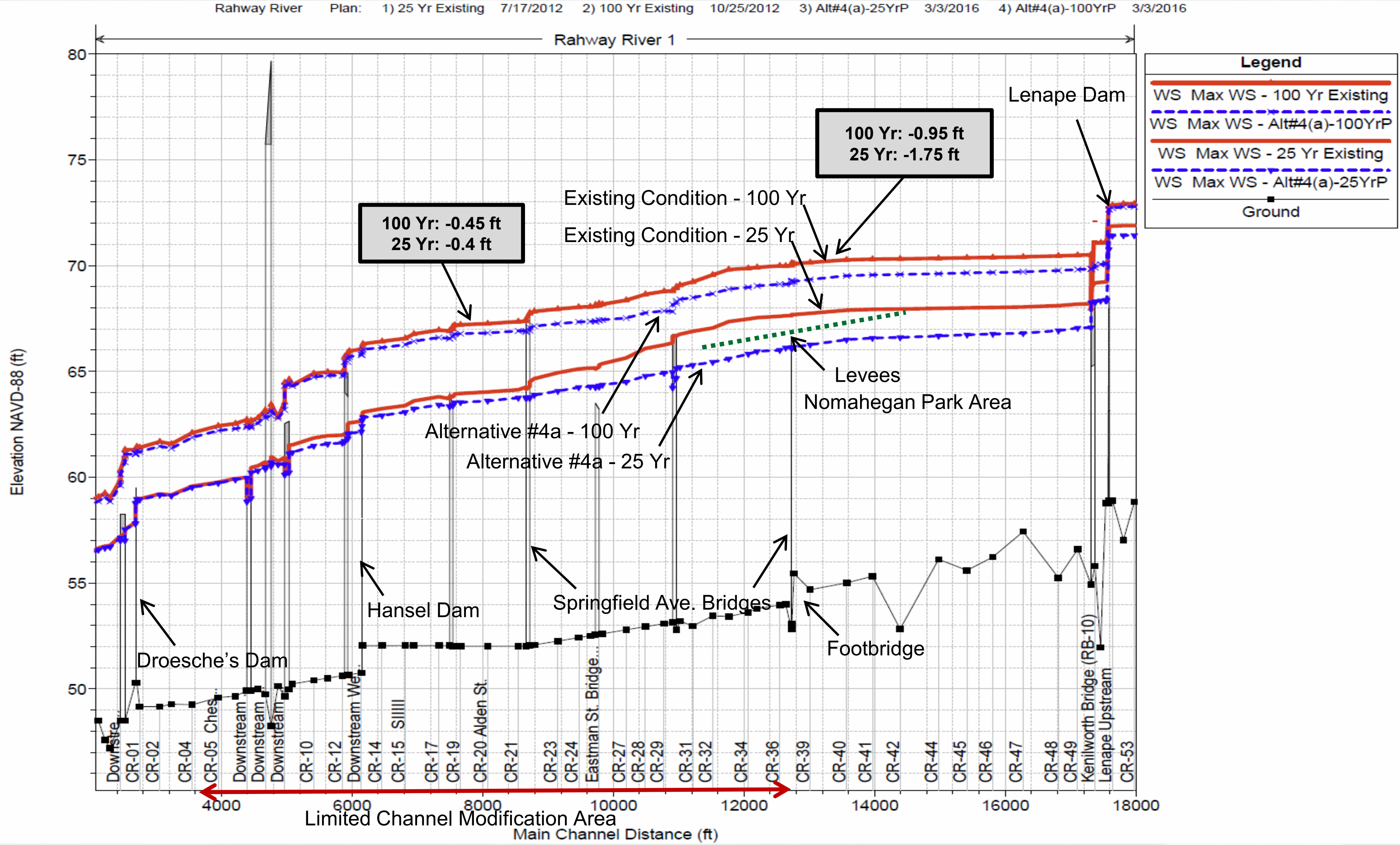
TSP: Cranford Channel Improvement and Orange Reservoir Replacement & Outlet Modification

TSP: Approximate Inundation Mapping 4% (25-Yr) Flood Cranford, Kenilworth and Springfield

TSP: Springfield and Lower Millburn
Reduction in 1% and 4% chance (100 Yr & 25-Yr) floods



TSP: Cranford
Reduction in 1% and 4% (100 yr & 25 yr) floods



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TSP: Orange Reservoir Dam Details

- Orange Reservoir Dimensions and Use

Details	Existing	Improved	Units
Height	34	34	ft
Length	900	900	ft
Capacity	774	774	ac-ft
Hazard Classification	High Hazard (NJDEP)		
Condition	Good/Fair		
Usage	Recreational	Recreational / Flood Risk Management	

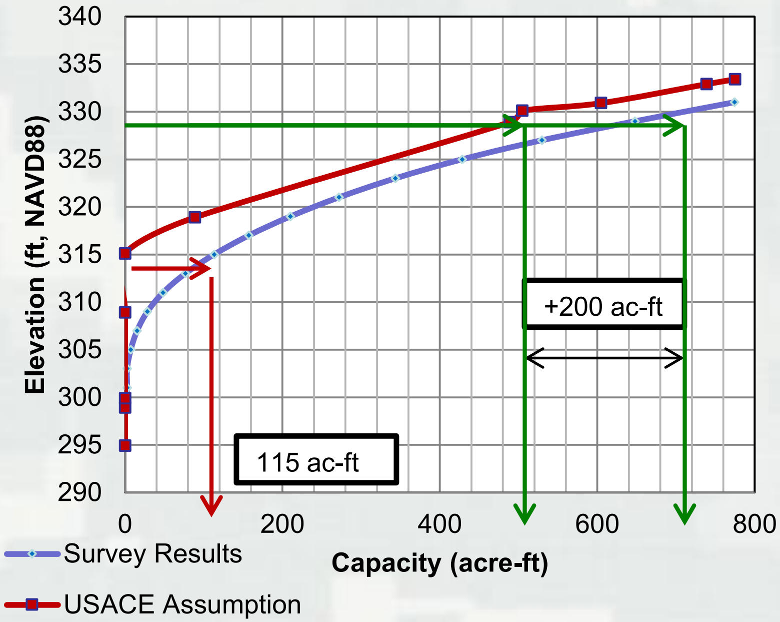
- Pre-storm drawdown will be approximately 15 ft from spillway elevation (330 ft)
  - At elevation 315 ft there will be about 22 acres under as much as 16 ft of water.

- Orange Reservoir Re-fill Times:

Events	Time
Drawdown Time	2 days
25 yr	30 hrs to re-fill
1 yr	One week to re-fill
Base Flow	Two weeks to re-fill
*Maximum drawdowns and re-fill depth = 15 ft	

Orange Reservoir Survey Results

Orange Reservoir Capacity vs. Elevation



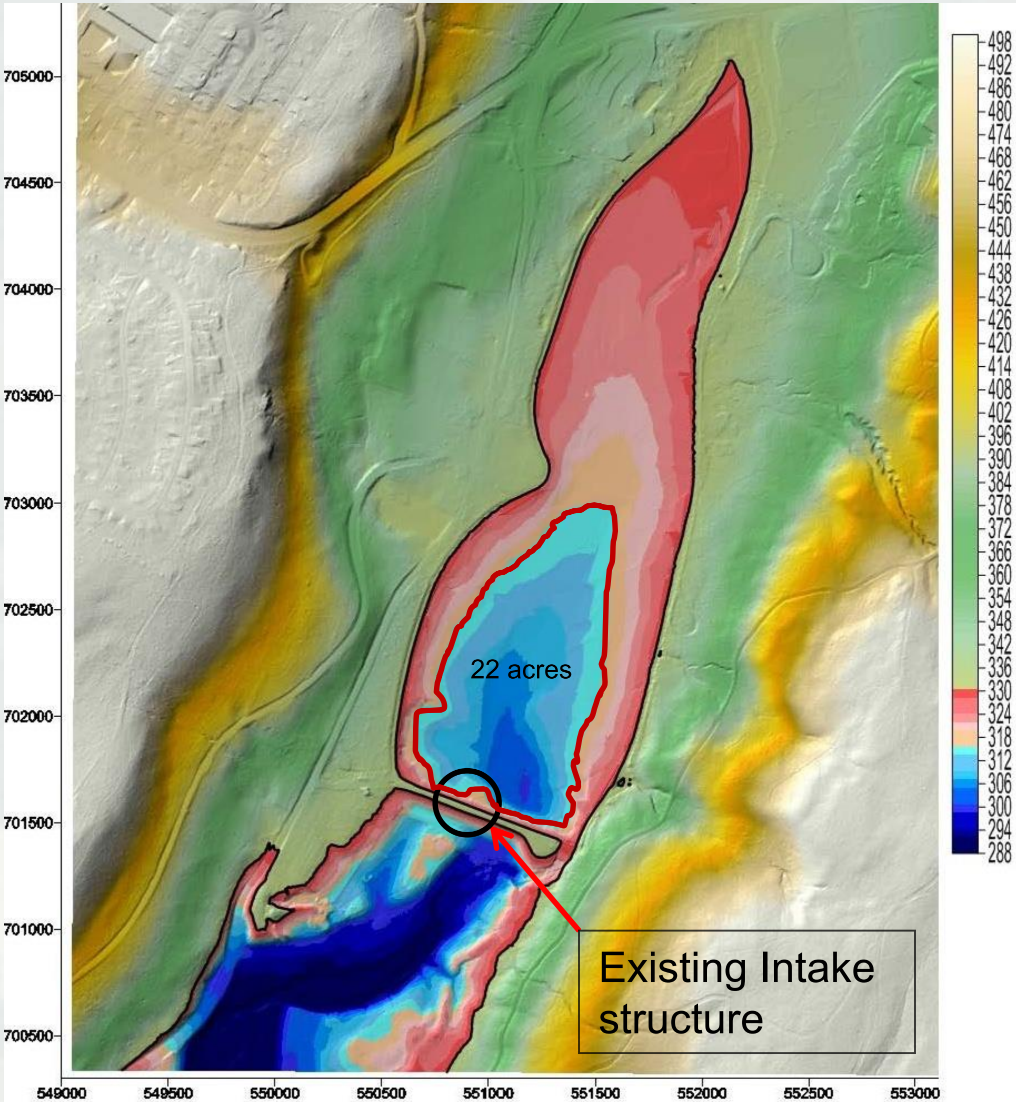
At the spillway elevation (330 ft NAVD), USACE assumed approximately 500 acre-ft of storage. The survey indicated that there is approximately 700 acre-ft of storage.

Orange Reservoir re-fill times:

Events	Time
Drawdown Time	2 days
25 yr	30 hrs to re-fill
1 yr	One week to re-fill
Base Flow	Two weeks to re-fill

*Maximum drawdowns and re-fill depth = 15 ft

Bathymetric Data



Orange Reservoir Concerns

- Reservoir is over 100 years old
- New Corps PMP/PMF* is significantly larger than the State's current value.
- Main Spillway is undermined.
- Overflow Spillway maybe under designed and the energy dissipation could be insufficient.
- Orange Reservoir Dam must meet the Corps' design standards & regulations once it's part of the Corps project.
- Geotech/structural data is not available, a cost estimate will be developed with worst case assumption.
- Full dam assessment will be performed during design phase such as:
  - H&H analyses;
  - Failure mode analysis;
  - Structural analysis;
  - Seepage analysis;
  - Geotechnical evaluation;
  - Seismic Analysis

*Probably Maximum Precipitation (PMP) and Probably Maximum Flood (PMF)

Orange Reservoir – Downstream Face

Orange Reservoir – Downstream Toe

Orange Reservoir – Main Spillway

Enclosure 3: Summary of Key Impacts and Mitigation

1.0 Summary of Impacts

1.1. Water Resources: Approximately 8,930 linear ft of Rahway River associated with channel improvements in Cranford Township; complete drawdown of the Orange Reservoir to construct dam replacement; partial drawdown prior to storm events.

1.2. Vegetation

1.2.1. Uplands: Approximately 1.09 acres associated with creating the 50 ft vegetation free zone around the Orange Reservoir dam

1.2.2. Riparian: Approximately 15 acres associated with the Cranford Township channel improvement construction.

1.2.3. Wetlands: Approximately 0.13 acres of forested deciduous wetlands assocatied with creating the 50 ft vegetation free zone around the Orange Reservoir dam.

2.0 Summary of Mitigation

2.1. Water Resources

- Constructing from one side of bank with preference to keeping vegetation on the western bank to optimize thermal impact reduction.
- Constructing the channel in a manner that contains baseflows, accentuates meanders within the channel, creates pool and riffle complexes and maintains velocities to sustain maintain transport. This may be achieved either through the excavation of a low flow channel or contouring the bottom of channel to direct flows in a certain direction within the channel.
- Restoring the existing substrate by stockpiling the gravel/cobble substrate excavated from the channel during construction and re-installing it once grading is completed.
- Native herbaceous material will be applied to the riverbanks in order to maintain the hydraulic efficiency of the channel during storm events. Native shrubs and trees will be planted on the top of bank.

The specific mitigation type and location will be identified during the Preconstruction Engineering Design Phase. Open water and vegetation mitigation will be monitored for a period of five years. The District will utilize using the Northern New Jersey Fish Index of Biological Integrity and the New Jersey High Gradient Macroinvertebrate Indices and the companion Environmental Protection Agency Rapid Bioassessment Protocol Stream Habitat Assessment Form to evaluate stream recovery.

Adaptive management measures will be implemented as necessary to achieve mitigation goals.

2.2. Vegetation

2.2.1. Uplands: Restore or enhance existing upland forest at 1:1 mitigation ratio

2.2.2. Riparian: Per New Jersey Department of Environmental Protection Flood Hazard Area Control Act Rules, riparian mitigation can be accomplished as follows:

- Creation (e.g. restoring a regulated water by removing a structure such as a pipe or culvert): 1:1 mitigation ratio
- Restoration (e.g. removal of impervious surface from top of bank): 2:1 mitigation ratio
- Enhancement (e.g. removal and replacement of invasive plant species with native species): 3:1 mitigation ratio
- Purchase of mitigation credits from a New Jersey Department of Environmental Protection mitigation bank.

2.2.3. Wetlands: Per the NJDEP Freshwater Wetlands Protection Act Rules, wetland mitigation can be accomplished as follows:

- Purchase of mitigation credits from a NJDEP wetland mitigation bank: 1:1 mitigation ratio;
- Wetland creation/restoration: 2:1 mitigation ratio
- Wetland enhancement: minimum 3:1 mitigation ratio

The specific mitigation type and location will be identified during the Preconstruction Engineering Design Phase. All mitigation will be monitored for a period of five years and adaptive management measures will be implemented as necessary to ensure mitigation success.

2.3. Fish and Wildlife

2.3.1. Fish

- Per NJDEP requirements, will implement an in-water restriction from 1 May through 30 June to protect spawning species;
- As per NJ Division of Fish and Wildlife Water Lowering Permit, the District will perform a fish salvage prior to the complete drawdown of the Orange Reservoir
- As per NJ DFW Water Lowering Permit, the District will perform the drawdown of the Orange Reservoir between mid-September through October.

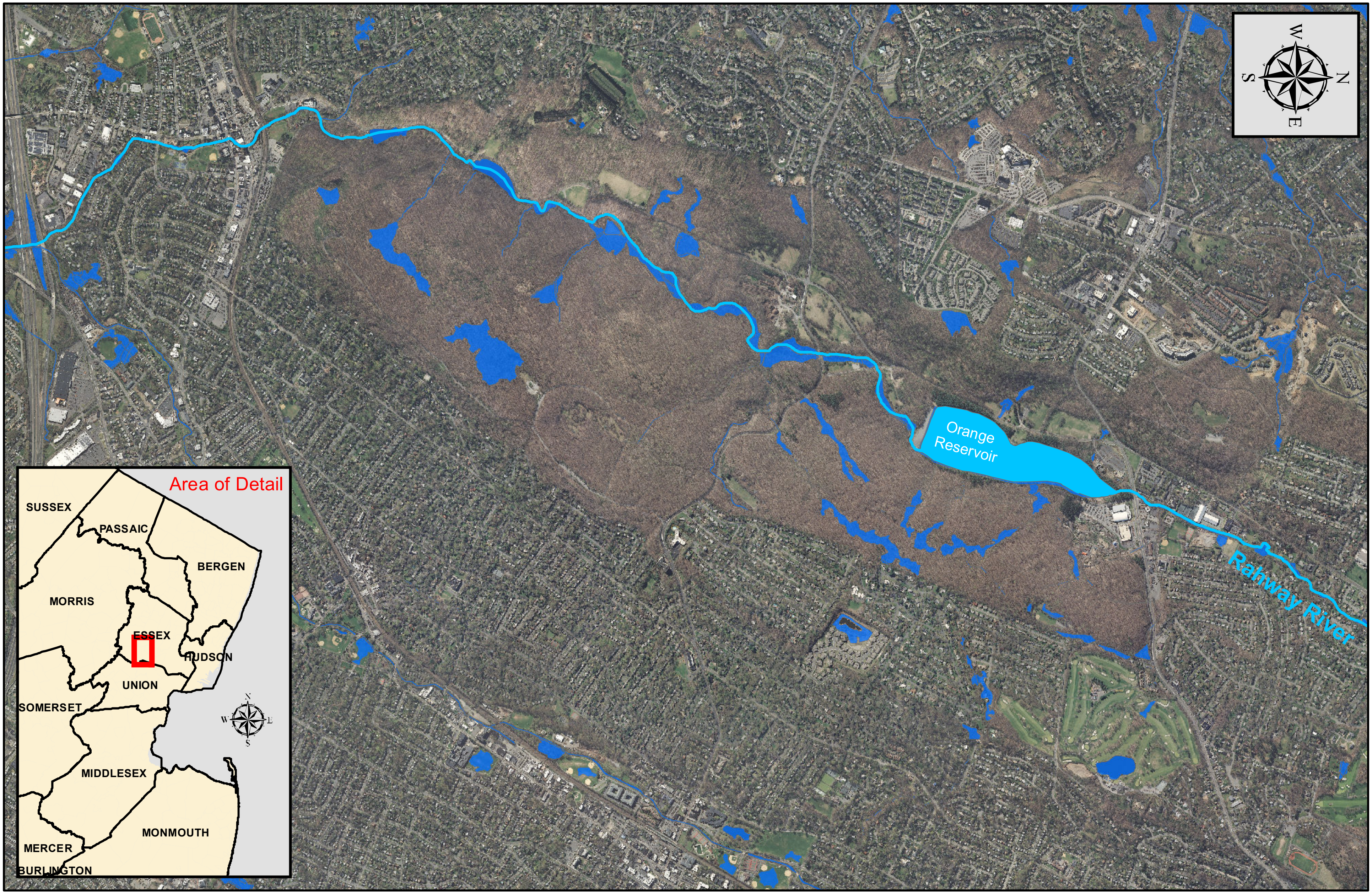
2.4. Endangered and Threatened Species

2.4.1. Indiana and Northern Long Eared Bat:

- Implementation of tree clearing restriction from 1 April through 30 September
- Conduct presence/abasence surveys if the tree clearing restriction cannot be implemented.
- Utilize tree species preferred by these species for summer roosting as part of upland, riparian and upland mitigation.

2.4.2. American Bald Eagle

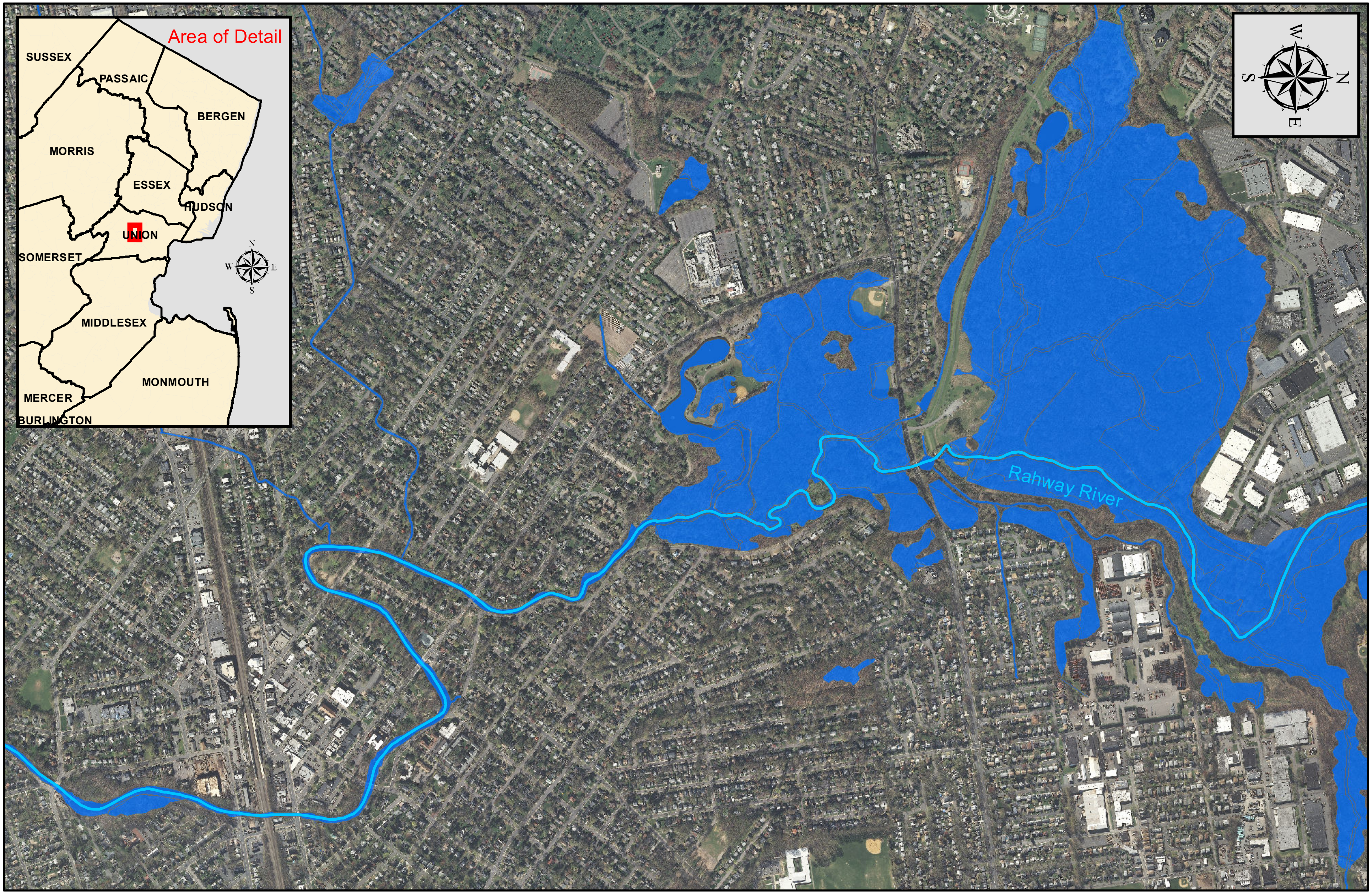
- Implementation of shrub and tree clearing restriction from 15 March through 31 July in accordance with the Migratory Bird Treaty Act
- Continue coordination with USFWS during construction and implement additional protective measures as outlined in the National Bald Eagle Management Guidelines as necessary.



US Army Corps of Engineers®
New York District

South Mountain Reservation Area

Rahway River Flood Risk Management Study
Essex County, New Jersey



US Army Corps of Engineers®
New York District

Cranford Area
Rahway River Flood Risk Management Study
Union County, New Jersey

0 0.25 0.5 0.75 1 Miles

Wetlands (US Fish & Wildlife NWI wetlands and NJ Department of Environmental Protection 2012 LULC wetlands)

Moyle, John

From: Moyle, John
Sent: Tuesday, January 05, 2016 3:45 PM
To: Moyle, John
Subject: FW: Rahway

From: Davis, Kelly
Sent: Tuesday, January 05, 2016 3:26 PM
To: Shaffer, Darin; Moyle, John
Cc: Hatala, Sarah
Subject: Re: Rahway River - Request for NJ Endangered and Nongame Species Program POC

I spoke with Fisheries and Endangered & Non-game Species Program - no huge red flags.

A time restriction from 5/1 thru 6/30 is recommended on any sediment generating activities associated with the project in order to protect warm-water fish nest building and spawning.
Species Occurrence Area (v11) and Landscape mapping (v3.1) indicates valued habitat and threatened / endangered (T / E - *Federally listed*) and "species of concern" in the area. (*Indiana Bat, Northern Long-eared Bat*, Red-shouldered Hawk) "Great Blue Heron, Little Blue Heron, Snowy Egret, Glossy Ibis, Wood Thrush."

For Indiana Bats and/or Northern Long-eared Bats:
-Seasonally restrict clearing of trees greater than 5 inches dbh from April 1 to September 30 within the geographic summer range of the Indiana or Northern Long-eared bat. Extend the seasonal restriction to November 15 if within 10.0 miles of a hibernaculum. *This location is within 10 miles of a Hibernaculum*
-Minimize tree clearing, especially of highly suitable roost trees including snags (dead trees), shagbark hickories (*Carya ovata*), other trees with shaggy or exfoliating bark, and trees of any species over 26 inches dbh
The Endangered and Non-game Species Program (ENSP) would generally concur with conditions imposed by USFWS.

For Red-shouldered Hawk: (western end of project area)
For activities within the nest buffer that might disturb the nest a timing restriction from March 1 to July 15 is recommended.

For nesting birds:
A general timing restriction on mechanical trimming or removal of trees (using heavy equipment) from 3/15 – 7/31 is recommended to protect nesting birds covered under the Migratory Bird Treaty Act. Non-mechanical tree trimming or removal (using chainsaws) may be permitted once the tree is checked for nesting activity.

General concerns:
The slope of the berm should be less than 45 degrees to allow turtles and other small animals to move over it.
BMP's for prevention of sediment movement should be used at all times and maintained for function.
Mitigation may be requested and/or required.

Kelly Davis, Biologist - Fisheries
N.J. Division of Fish and Wildlife - Office of Env. Review
P.O. Box 394, 1255 County Rt. 629

Moyle, John

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Sent: Tuesday, January 05, 2016 3:45 PM
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Kelly Davis, Biologist - Fisheries
N.J. Division of Fish and Wildlife - Office of Env. Review
P.O. Box 394, 1255 County Rt. 629

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609-646-9310 Fax: 609-646-0352
http://www.fws.gov/northeast/njfieldoffice

IN REPLY REFER TO:
15-CPA-0063

FEB 20 2015

Peter Weppler, Chief
Environmental Analysis Branch, New York District
U.S. Army Corps of Engineers
Jacob K. Javits Federal Building
New York, New York 10278-0090
Attention: Kimberly Rightler

Planning Aid Letter for the Rahway River Basin Flood Risk Management Feasibility Study, Essex, Middlesex and Union Counties, New Jersey.

Dear Mr. Weppler:

The U.S. Fish and Wildlife Service (Service) has prepared this Planning Aid Letter (PAL) for the Rahway River Flood Risk Management Feasibility Study, Cranford, Union County, New Jersey (Feasibility Study) in accordance with a fiscal year 2012 Scope of Work (SOW) and interagency agreement pursuant to the Fish and Wildlife Coordination Act of 1958 (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) (FWCA). This PAL does not constitute the report of the Secretary of the Interior as required by Section 2(b) of the FWCA. The purpose of this PAL is to provide input, guidance and recommendations to the U.S. Army Corps of Engineers (Corps) regarding resource conservation issues for the planning stages of the Feasibility Study. Comments provided in this PAL are based on information the Corps provided to us, site visits, field notes, site photographs, maps, and analysis of Geographic Information Systems data sets (ArcGIS® version 10.0). As identified in our SOW for this Feasibility Study, this PAL assists the Corps in formulating and evaluating the feasibility of implementing flood risk management measures within the 500-year floodplain portion of the Rahway River Basin located in the Township of Cranford.

AUTHORITY

The Corps and the Service coordinate during project planning to conserve, protect, and enhance fish, wildlife, and plants and their habitats. Legislation relevant to natural resource protection for this project includes the FWCA, the Endangered Species Act of 1973 (87 Stat. 884, as amended; (16 U.S.C. 15.31 *et seq.*) (ESA), the National Environmental Policy Act of 1973 (83 Stat. 852; as amended, 42 U.S.C. 4321 *et seq.*) (NEPA), the Migratory Bird Treaty Act (40 Stat. 755; 16 U.S.C. 703-712) (MBTA), and the Bald and Golden Eagle Protection Act (BGEPA) (54 Stat. 250 as amended; 16 U.S.C. 668-668d). In addition, several Executive Orders have also established guidance to Federal agencies, including the Service, relative to fish and wildlife protection and conservation. For projects authorized under Water Resource Development Act (33 U.S.C. 2201 *et seq.*), the ESA and the FWCA represent the primary authorities under which the Service cooperates and coordinates with the Corps. The following comments constitute planning aid and do not address all Service concerns for fish and wildlife resources and do not preclude separate review and comments by the Service pursuant to the December 22, 1993 Memorandum of Agreement among the U.S. Environmental Protection Agency, New Jersey Department of Environmental Protection (NJDEP), and the Service, if project implementation requires a permit from the NJDEP pursuant to the New Jersey Freshwater Wetlands Protection Act (N.J.S.A. 13:9B *et seq.*); nor do they preclude comments or recommendations on any documents prepared pursuant to NEPA. Any NEPA document (Environmental Assessment or Environmental Impact Statement) will be prepared in accordance with the Council on Environmental Quality's regulations for implementing NEPA (40 CFR Parts 1500-1508), and Corps regulations and policies.

INTRODUCTION

This Feasibility Study is designed to identify flood risk management measures that will reduce the incidence and severity of flooding in the Rahway River Basin, particularly in Township of Cranford. It was authorized by Section 204 of the Flood Control Act of 1965 (P.L. 89–298) and U.S. House of Representatives Resolution Docket 2548, adopted March 24, 1998. The goal of the Feasibility Study is to identify opportunities for future flood damage reduction and associated environmental restoration. During preliminary review, the Corps has evaluated approximately 10 different alternative plans and determined that three meet cost/benefit criteria required for further consideration. One of these plans, identified as *Alternative 6: South Mountain Regional Detention Basin*, has been withdrawn by the Corps due to widespread public and municipality opposition (K. Rightler, personal communication, September 18, 2014). The two proposed plans currently under consideration are *Alternative 4: Channel Improvements and minor modification to Orange Reservoir*, and *Alternative 7a: Non-Structural Plan for10-year Floodplain* (Corps 2014a).

Primary elements of the proposed Alternative 4 include channel modification of approximately 15,500 feet of the Rahway River in Cranford; the removal or replacement of up to 2,000 feet of existing floodwalls (Corps 2014b); the removal of two dams; the reconstruction of two bridges; and the installation of new outlet pipes at Orange Reservoir located approximately 10 miles upstream (Corps 2014a). The proposed channel would extend downstream from Kenilworth Avenue to the site of Droescher's Dam. It would have trapezoidal side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal. Under this plan, the river channel would be deepened to attain a downstream slope of approximately 2.6 feet per mile, with a maximum excavation of about 3.7 feet near Hansel Dam. The river channel would be reconstructed to a final width of 60 feet. Channel modifications would also include the construction of diversion channels at two locations, where meanders would be isolated to straighten the river. Together these diversions would create approximately 250 feet of new channel and eliminate approximately 1,300 feet of existing channel. The Union Avenue and North Avenue bridges over the Rahway River in Cranford would be removed and replaced by bridges of design that open the river channel to greater flow. Also in Cranford, both Droescher's Dam (above Lincoln Avenue East) and Hansel Dam (above Union Avenue North) will be removed to increase river flow. At Orange Reservoir, located in West Orange Township approximately ten miles upstream from Cranford, two manually operated 30 inch outlet pipes would be installed to allow drawdown of the reservoir in advance of predicted rainfall events. It is anticipated that the flow detention capacity of the Orange Reservoir would mitigate the increase in flow conveyance capacity obtained by deepening and widening the channel (Corps 2014a). Implementation of Alternative 4 will require mitigation measures due to the permanent loss or alteration of approximately 15,500 feet of Rahway River channel, 27 acres of riparian zone, and 7.25 acres of wetlands. Estimated cost for Alternative 4 is $68.9 million (Corps 2014b).

Alternative 7a proposes non-structural flood damage reduction measures in Cranford within the 10% annual exceedance (10-year event). Implementing Alternative 7a would affect a total of 66 structures (elevate 62, buyout two, wet flood proof one, and ringwall one) at a cost of approximately $15.3 million (Corps 2014b).

The Corps is also evaluating the feasibility of two other proposed flood control measures not included in the cost/benefit analysis (K. Rightler, personal communication, September 18, 2014). One would utilize elements of Alternative 4 (the new Orange Reservoir outlet pipes) and the rejected Alternative 1 (extending the height of levees and floodwalls in Lenape Park). This proposed plan would remove the channel modification component included in both Alternatives 1 and 4. A second proposed plan would utilize elements of a plan proposed in 1985 for flood control measures on Robinsons Branch above its confluence with the Rahway River in the City of Rahway. It includes the channelization of approximately 6,600 feet of Robinsons Branch; 800 feet of dike along St. Georges Avenue; 5,000 feet of levee; and a 200-foot segment of floodwall.

STUDY AREA

The Rahway River basin covers approximately 83-square miles of Essex, Middlesex and Union Counties of New Jersey (Fig. 1). From its source at Crystal Lake, at an elevation of approximately 520 feet, the Rahway River flows for 24 miles before terminating at sea-level in Arthur Kill, the tidal strait separating Staten Island, New York City, New York from mainland New Jersey. The Rahway River basin encompasses 24 municipalities in ten sub-watersheds and, according to the 2010 United States Census, is one of the most densely populated areas in the U.S. Suburban and urban land use in the basin was well established with development occurring well prior to enactment of New Jersey's Stormwater Management rules (N. J. A. C. 7:8) in February 2004, which requires stormwater management measures for development activities. The considerable amount of impervious surfaces in the basin -- such as streets, parking lots, rooftops and compacted soil -- have greatly reduced the amount of rainfall infiltration and capacity for stormwater retention. The steep gradient of the sub-watersheds above Cranford, combined with increased runoff from development, adds to the potential for severe flooding during periods of heavy rainfall. For the proposed flood risk management activities, the Feasibility Study area is defined as being upstream from the confluence of Robinsons Branch and the Rahway River in the City of Rahway, approximately five miles downstream from Cranford.

Communities along the Rahway River been effected in recent years by flooding from events such as Tropical Storm Floyd in September 1999, the April 2007 Nor'easter, and Hurricane Irene on August 27-30, 2011 (Corps 2014a). The U.S. Geological Survey recorded up to 9.9 inches of rainfall in the Rahway River basin during Hurricane Irene and a total of 20 inches for the month of August (USGS 2013). The resulting flooding peaked at greater than the 500-year recurrence interval (< 0.2% annual-exceedance probability) in the City of Rahway, where the river crested at 2.5 feet higher than the previous peak for 90 years of record; and at greater than the 100-year recurrence interval (1% annual-exceedance probability) at Springfield, located 2.5 miles upstream from Cranford, where the river crested at its highest peak for 74 years of records (Watson *et al.* 2014). While there is no official flood gauge in Cranford, it was the site of some of the worst flooding that occurred during Hurricane Irene (Corps 2014a).

ENVIRONMENTAL CONDITIONS

Geography

The Rahway River Basin lies entirely within the Piedmont physiographic province of northern New Jersey. The Piedmont includes low mountains, ridges, and hills, but is primarily lowland with smooth, rounded hills that slope gently toward the Coastal Plain. The ridges of the Watchung Mountains that form the western border of the Rahway River Basin (and the West Branch watershed) are made of hard, erosion resistant volcanic basalts. The rest of the basin consists of a gently rolling plain that is part of a glacial moraine of a late-Wisconsinan ice sheet. The highest points in the basin are near 630 feet in elevation along the crest of First and Second Mountains, while the plain that forms most of the basin ranges from 150 feet at the eastern side of the Watchungs to sea level on the eastern boundary of the county at the Arthur Kill.

Hydrology/topography

The Rahway River basin encompasses 12 sub-watersheds. Upstream from the confluence of Robinsons Branch in the City of Rahway, runoff from nine sub-watersheds totaling 62 square miles flow to the Rahway River. The primary area of focus for the Feasibility Study includes 36 square miles within 4 sub-watersheds upstream from Cranford. Three major tributaries enter the Rahway River above Cranford, including Nomahegan Brook, and the East Branch and West Branch of the Rahway. All three of these tributaries originate at highest elevations of the basin: over 500 feet in the Nomahagen sub-basin and over 600 feet in the East and West Branch sub-basins. Waterways in these sub-watersheds descend steeply down to the Cranford area, where the stream gradient decreases dramatically (Fig. 2). From Orange Reservoir downstream to Springfield the Rahway River gradient averages 41 feet per mile. From Springfield to Cranford the gradient is approximately 2.6 feet per mile, then below Cranford the gradient increases to about 8.2 feet per mile downstream to the City of Rahway and Arthur Kill.

Soils

Soils in the Rahway River Basin are dominated by Booton and Haledon series soils. These soils account for over 70 percent of the land area in sub-watersheds above the City of Rahway. Both are sandy loam soils formed in glacial till. Booton series soils are generally coarser and located further upslope than Haledon series soils. Both Boonton and Haledon series are Hydrologic Group C soils. Group C soils are described as sandy loam soils having low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure (Natural Resources Conservation Service 2002). The Booton series are described as "well drained" to "moderately well-drained" soils with water table at a depth of more than 80 inches. Runoff rates may be slow or rapid. Water storage capacity is rated low (5 inches) because of an impermeable fragipan layer at 24 to 36 inches. The fragipan results in a perched water table between November and May most years. Haledon Series soils are classified as "somewhat poorly drained", have medium to very high runoff rates, and a water storage capacity rated as low (5 inches). Soil permeability is slow to moderately rapid above the fragipan layer (at a depth of 20 to 36 inches) and moderately rapid to rapid below. Haledon soils also have a perched water table between November and May most years.

Soil conditions within the basin have been altered greatly by development. Over 68 percent of the soils above Rahway are described as urban (covered by hard surfaces) or urban complex (at least the top 12 inches have been disturbed) soils. The underlying soils are predominately of the Boonton and Haledon series, retaining their deeper soil horizon characteristics.

Wetlands and Vernal Pools

As is the case with upland areas of the Rahway River Basin, wetlands and waterways have been significantly altered over the years. GeoWeb mapping indicates that in its 24 mile course, only about three miles of original channel exists today (NJDEP 2015). Most of that channel is located in the South Mountain Reservation, and all is above the municipality of Milburn, some five miles upstream from Cranford. Most of the basin's remaining wetlands lie along the Rahway River and its tributaries.

The largest wetland areas in the Study Area are located in the Rahway River floodplain adjacent Lenape and Nomahegan Parks. The proposed channel modifications included in the proposed Alternative 4 would run through palustrine forested wetlands in Nomahegan Park. These wetlands are classified by National Wetland Inventory Mapping Convention as PFO1A (seasonally flooded), PFO1C (temporarily flooded), and PFO1E (seasonally flooded/saturated). Description of Alternative 4 components contained in a document titled "Formulating Alternative Plans" provided by the Corps (K. Rightler, personal communication, September 18, 2014), state that 1400 feet of modified channel would be within Nomahegan Park. However mapping indicates that approximately 3,300 feet of the proposed channel would be in Nomahegan Park, a number that excludes about 1,000 feet of river channel within the park that would be lost due to channel realignment. The majority of Nomahegan Park, and all lands near the river, are mapped as wetlands. Deepening the river channel will have a negative impact on the park's wetlands due lowered water table and reduced seasonal and temporary flooding into the floodplain, not only adjacent to the river channel, but also to wetlands along small tributaries flowing into the river within the park.

There are two vernal pool habitat areas are noted along the Rahway River, one above Lenape Park and the other within South Mountain Reservation. Vernal pools are unique ecological systems supporting distinctive plant and animal species. Typically inundated in the spring and dry during the summer, vernal pools provide safe habitat for amphibian and insect species unable to tolerate competition or predation by fish. Given the scarcity of wetland and vernal pool habitat within the Rahway River Basin, maintaining these hydrologically sensitive areas is imperative for the protection of fish and wildlife resources.

Environmental Contaminants

A review of existing government data bases identified a total of 55 active or pending contaminated sites within the project area, defined as 1/8 mile on either side of Robinsons Branch and the Rahway River south from State Route 22 to their confluence. The total area reviewed totaled 1,650 acres, including 383 acres of Lenape Park and 119 of Nomahagen Park in Cranford. Looking at the entire watershed above the confluence of Robinsons Branch and the Rahway River, a New Jersey GeoWeb database review identified a total of 374 known contaminant and an additional 54 locations that have active ground water contamination. Six of these sites are located on or adjacent to levees/dike/floodwall sites included in the 1985 proposal for Robinsons Branch. Along the east side of the Rahway River in Union, just upstream from the Lenape Park area, is an approximately 18 acre contaminated groundwater area that may be discharging into the river.

New Jersey's surface water quality standards (SWQS) establish stream classifications and the designated uses for all waters of the State. Designated uses include aquatic life support (maintenance, migration, and propagation), recreation, fish consumption, shellfish harvest for consumption, drinking water supply, industrial water supply, and agricultural water supply. The SWQS makes a determination at the sub-watershed level that water quality either "fully supporting" of the use, "not supporting" of the use, or lacking sufficient information to make an assessment. The most recent assessment of the Rahway River found that water quality in the sub-watershed between Robinsons Branch and Kenilworth Avenue, which includes the Feasibility Study area, was "not supporting" of aquatic life (total phosphorus, dissolved oxygen, total dissolved solids), fish consumption (mercury in fish tissue), industrial water supply (total dissolved solids), primary water contact (fecal coliform), or public water supply (arsenic) (NJDEP 2010). Sources of contaminants were identified as: 1) combined sewer overflows; 2) industrial point source discharge; 3) urban runoff/storm sewers; 4) agriculture; 5) atmospheric deposition – toxics; and 6) natural sources. Water quality was "fully supporting" of agricultural water supply (NJDEP 2010). An average of 5.3 million gallons of water per day is collected from this stretch of river to provide drinking to about 26,500 residents in the City of Rahway.

Testing of fish tissues has identified levels of contaminants that have led NJEDP to issue consumption advisories for fish throughout the Rahway River system. The general population is advised to eat only one meal per week for largemouth bass (*Micropterus salmoides*), bluegill sunfish (*Lepomis macrochirus*), and brown bullhead (*Ameiurus nebulosus*), and only four meals per year for common carp (*Cyprinus carpio*). High-risk individuals, including infants, children, pregnant women, nursing mothers and women of childbearing age are advised not to eat largemouth bass or common carp, and only one meal per month of bluegill sunfish or brown bullhead. Statewide, the general population are advised to eat only one meal per week of trout, smallmouth bass (*Micropterus dolomieu*), and pickerel (*Lepomis macrochirus*), while high-risk individuals are advised to eat only one meal per week of trout and sunfish, and only one meal per month of smallmouth bass, pickerel, and yellow bullhead.

Federally Listed Species

Bog Turtle

The Study Area contains wetlands that could support populations of the federally listed (threatened) bog turtle (*Clemmys muhlenbergii*), specifically the large wetland area known as the Ash Brook Swamp Reservation, located along Robinsons Branch in Scotch Plains Township, Union County, approximately four miles upstream from its confluence with the Rahway River. Bog turtles inhabit open, wet meadows and bogs with standing or slow-moving, shallow water over a mucky substrate. Bog turtles also occur in emergent and shrub/scrub wetlands and spring-fed fens. For more information, please refer to the enclosed narrative on the biology and threats to bog turtle.

Indiana Bat

Potential summer habitat for the federally listed (endangered) Indiana bat (*Myotis sodalis*) is present throughout the project area. Hibernacula are located approximately 20 miles northwest from Lenape Park and maternity colonies have been identified within seven miles. Indiana bats utilize loose bark or crevices in trees for daytime roosts and forage on flying insects below the forest canopy and along riparian corridors. In areas of potential habitat for Indiana bat, seasonal restrictions for tree removal are recommended from April 1 through September 30. For more information, please refer to the enclosed narrative on the biology and threats to Indiana bat.

Northern Long-eared Bat

Potential summer habitat for the federally proposed listed (endangered) northern long-eared bat (*Myotis septentrionalis*) is present throughout the project area. Under Section 7(a)(4) of the ESA, a Federal agency must confer with the Service on any agency action that is likely to jeopardize the continued existence of any species that the Service has proposed to be listed, or that is likely to result in the destruction or adverse modification of critical habitat proposed to be designated for such species. The northern long-eared bat has a similar life history as the closely related Indiana bat, roosting in trees and foraging on flying insects. In areas of potential habitat for northern long-eared bat, seasonal restrictions for tree removal are recommended from April 1 through September 30. For more information, please refer to the enclosed narrative on the biology and threats to northern long-eared bat.

Species under Review for Federal Listing

The Service is evaluating the little brown bat (*Myotis lucifugus*), tri-colored bat (*Perimyotis subflavus*), and American eel (*Anguilla rostrata*) to determine if listing under the ESA is warranted. American eel is known to be present in the project area and the bat species may be present. These species do not currently receive any substantive or procedural protection under the ESA, and the Service has not yet determined if listing of any of these species is warranted. However, the Corps and other Federal action agencies should be aware that these species are being evaluated for possible listing and may wish to include them in field surveys and/or impact assessments, particularly for projects with long planning horizons and/or long operational lives.

Other Federally Listed Species

Except for bog turtle, Indiana bat and northern long-eared bat, no other federally listed or proposed threatened or endangered flora or fauna are known to occur in the vicinity of the project site. If additional information on federally listed endangered or threatened species becomes available, this determination may be reconsidered.

State-Listed Species and Species Protected by Other Laws

Bald Eagle

Nesting and foraging habitat for the bald eagle (*Haliaeetus leucocephalus*) may occur in the Project's area. The bald eagle was removed from the Federal List of Endangered and Threatened Wildlife effective August 8, 2007. The bald eagle continues to be protected under the BGEPA and MBTA. The bald eagle also remains a State-listed species under the New Jersey Endangered and Nongame Species Conservation Act (N.J.S.A. 23:2A *et seq.*) (NJENSPCA), These Federal and State laws prohibit take of bald eagles.

A known nest site of the bald eagle is located within 3 miles of the project site and suitable foraging areas exist throughout the proposed project area. Bald eagles occur in New Jersey throughout the year and have been expanding their range in recent years. For more information, please refer to the enclosed narrative on the biology and threats to bald eagles. For the continued protection of bald eagles, and to ensure compliance with Federal and State laws, the Service recommends minimizing impacts on bald eagles in accordance with the National Bald Eagle Management Guidelines and all applicable State regulations. Links to State agencies and the Guidelines are available on this office's web site at http://www.fws.gov/northeast/njfieldoffice/endangered.

State-Listed

Several avian species that are afforded protection under the NJENSPCA have been documented in the Rahway River basin area. State-listed endangered species include the pied-billed grebe (*Podilymbus podiceps*), short-eared owl (*Asio flammeus*), and northern goshawk (*Accipiter gentilis*). State-listed threatened species include the red-shouldered hawk (*Buteo lineatus*), barred owl (*Strix varia*), red-headed woodpecker (*Melanerpes erythrocephalus*), grasshopper sparrow, (*Ammodramus savannarum*), osprey, (*Pandion haliaetus*), horned lark (*Eremophila alpestris*), American kestrel (*Falco sparverius*), bobolink, (*Dolichonyx oryzivorus*), cattle egret (*Bubulcus ibis*), and black-crowned night heron (*Nycticorax nycticorax*). Regional priority species include the glossy ibis (*Plegadis falcinellus*) and little blue heron (*Egretta caerulea*). Species of concern in the project area that warrant special attention because of inherent vulnerability to environmental deterioration or habitat modification include the great blue heron (*Ardea herodias*), nighthawk (*Chordeiles minor*), Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), and eastern meadowlark (*Sturnella magna*). Please contact the New Jersey Division of Fish and Wildlife's (NJDFW) Endangered and Nongame Species Program (ENSP) for additional information regarding State-listed species.

Migratory Avifauna

The riparian forests, wooded wetlands, marshes, and grasslands along the Rahway River and Robinsons Branch corridors, including the Lenape Park and South Mountain Reservation areas, provide nesting and foraging habitat for over 100 different migratory avian species. Completion of the project may require removing trees, shrubs, or other vegetation. The MBTA prohibits taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. Neither the MBTA nor its implementing regulations at 50 CFR Part 21 provide for permitting of "incidental take" of migratory birds.

Tree cutting and/or shrub removal can adversely affect migratory birds if conducted during the nesting season. The MBTA prohibits taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. Neither the MBTA, nor its implementing regulations at 50 CFR part 21 provide for permitting of "incidental take" of migratory birds. According to the New Jersey Division of Fish and Wildlife Guidance Manual for the protection of Fish and Wildlife Resources dated July 2008, the appropriate timing restriction to protect nesting migratory birds from tree or shrub/scrub removal is March 15 to July 31. While nests without birds or eggs are not protected under the MBTA, nest destruction that results in the unpermitted take of migratory birds or their eggs and unfledged chicks is illegal. The Service recommends implementing the aforementioned seasonal restriction to any proposed tree/shrub removal.

Fisheries and Invertebrates

The Rahway River and its tributaries are classified by NJDFW as FW2 Non-Trout Waters (NJDEP 2005). The Fish Index of Biological Integrity (FIBI) classifies water pollution levels based on assessment of fish assemblages present in waterways. During 2000, 2005, and 2010 NJDFW conducted sampling in the Rahway River. The FIBI score calculated from each sampling rated Rahway River water quality as "fair" (NJDEP 2011). Fish species collected during these sampling periods include largemouth bass, bluegill, green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), redbreast sunfish (*Lepomis auritus*), American eel, black crappie (*Pomoxis nigromaculatus*), redfin pickerel, white sucker (*Catostomus commersoni*), yellow bullhead (*Ameiurus natalis*), common shiner (*Luxilus cornutus*), banded killifish (*Fundulus diaphanus*), spottail shiner (*Notropis hudsonius*), blacknose dace (*Rhinichthys atratulus*), mummichog (*Fundulus heteroclitus*), tessellated darter (*Etheostoma olmstedi*), golden shiner (*Notemigonus crysoleucas*), creek chub (*Semotilus atromaculatus*), and mosquitofish (*Gambusia affinis*). The Rahway River system provides the public with recreational fishing opportunities, as largemouth bass, bluegill, green sunfish, pumpkinseed, redbreast sunfish, black crappie, redfin pickerel, white sucker, and American eel are all identified as sport fishing species. While listed as non-trout water, each year NJDFW releases several thousand trout, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) into the Rahway River upstream from the City of Rahway.

No anadromous species or ocean migrant species that spawn inshore, such as herring (*Alosa spp.*) or striped bass (*Morone saxtilis*), are located in the Rahway River Basin above the City of Rahway. One catadromous species (*i.e.*, a species that moves from freshwater to the ocean to breed), the American eel, occurs within the waters of the basin. Although portions of the lower Rahway River support anadromous species, they would not be currently expected to occur in the Feasibility Study area due to several dams blocking upstream migration. Unlike anadromous fishes, the highly mobile American eel has the ability to move over land and around impediments to migrate to the sea for reproduction.

The NJDEP utilizes the Environmental Protection Agency's Rapid Bioassessment Protocols (RBPs) to help monitor the health of streams and watersheds. One protocol, termed Ambient Biological Monitoring Network (AMNET), examines dynamics of benthic macroinvertebrate populations to determine taxon present. Ratings of the stream condition are based on the biodiversity of the system and the level of pollution tolerance of the families collected, the ratio of pollution tolerant to pollution intolerant families such as members the insect orders Ephemoptera (mayflies), Plectoptera (stoneflies), and Trichoptera (caddisflies), often referred to as EPTs. The AMNET scoring system rates stream conditions as either "excellent", "good", "fair", or "poor'. Invertebrate sampling at three Rahway River sites (Rahway, Kenilworth, Springfield) during the most recent assessment in 2009 failed to detect any EPTs and scoring for each location rated as "poor" (NJDEP 2012).

A second RBP, used to determine riparian habitat quality evaluates in-stream substrate, channel morphology, bank structural features, and riparian vegetation at the sample site and the adjacent area within a 100 to 200 foot radius to calculate a habitat score. Compilation of a qualitative rating score of each parameter yields a habitat score of "optimal", "suboptimal", "marginal', or "poor'. Habitat scores calculated during the 2009 stream assessment rated each of the three Rahway River locations as "suboptimal" (NJDEP 2012).

Prior to adopting the AMNET protocol, the NJDEP macroinvertebrate bioassessment protocol utilized a single statewide index the New Jersey Impairment Score (NJIS), which assigned one of three assessment ratings: "non-impaired", "moderately impaired", and 'severely impaired". The NJIS protocol was replaced with AMNET in 2004 because it utilizes different indices for coastal, Pinelands, and high-gradient ecoregions, thus yielding more meaningful assessments (NJDEP 2012). While the NJIS and AMNET rating systems are different, some conclusions can be drawn in comparing data collected under each protocol. During the 1992 macroinvertebrate sampling, the Rahway River rated as "moderately impaired" (NJDEP 1994). This was due to the presence of substantial numbers of EPT pollution intolerant family Hydropsychidae (Trichoptera). The absence of EPT species in more recent sampling indicates water quality in the Rahway River has likely diminished in recent years.

SERVICE COMMENTS AND RECOMMENDATIONS

For the protection of fish and wildlife resources, the Service prefers non-structural options over channel modifications for flood risk management. While *Alternative #7a: Non-Structural 10-year Plan* calls for the buyout of only two properties, there is history of strong support from local municipalities and non-government organizations to purchase at-risk properties along the Rahway River and convert them to green space. The Service recommends the Corps to coordinate with the local municipalities, non-government organizations, and land owners in supporting buyout programs for at risk properties located beyond the 10% annual exceedance area (10-year event). Additionally, Alternative 7a is by far the least costly alternative.

The Service recommends close coordination among the Corps, National Marine Fisheries Service, NJDEP, NJDFW, ENSP, and New Jersey Natural Heritage Program to avoid potential adverse impacts of construction alternatives in association on fish and wildlife resources and habitats that may result should the Corps pursue any projects within this Study Area.

The Corps should pre-coordinate a project activities plan (*i.e.*, construction activities, operation windows, and equipment movement to include access/egress the project sites) with Federal and State resource agencies to avoid or minimize disturbance to fish and wildlife habitats associated with the target flood control and restoration areas.

In order to avoid and minimizing potential adverse impacts on sensitive natural resources and State-listed or Federally-listed species within the Study Area, the Service recommends incorporating the following measures into project planning.

- Forward results of any sediment testing to the Service for review. The Service understands that contaminants testing will be conducted on Project site sediments once plans have been finalized. The Service recommends that future project designs include information on sediment sources and disposal sites where fill or excavation may be required.

- The Corps preliminary impact assessment estimates that implementing channel modifications associated with Alternative 4 would result in the permanent loss or alteration of approximately 15,500 feet of Rahway River channel; 27 acres of riparian zone; and 7.25 acres of wetlands (Corps 2014b). It appears that channel modification within Nomahegan Park would not be 1,400 feet as described by the Corps, but close to 3,300 feet (plus an additional loss of about 1,000 feet of channel), so the total amount of affected wetlands would likely be considerably more than 7.25 acres. The Service recommends the Corps reevaluate its calculations of impacted wetlands and river channel and provide mitigation plans accordingly.

- The Service recommends mitigation measures for activities that result in the alteration of Rahway River channel that may include: excavation of a meandering low-flow channel within flood control channel, incorporating pool/riffle/run flow sequences that provide multiple habitat features and encourage colonization by diverse populations of aquatic organisms; extract any gravel/cobble components from excavated river channel materials and replace into channel after removing fine sediments; or the removal of downstream dams or creating fish passage structures for downstream dams to provide additional spawning habitat for diadromous fishes.

- The Service generally supports the removal of dams from streams and rivers. Alternative 4 calls for the removal of the Hansel and Droescher's Dams, which would open approximately two and one half miles of the Rahway River to fish passage. Because there are still at least three dams below Hansel Dam blocking upstream movement of anadromous and other fishes, the impact on diadromous fish of removing the dams would be minimal. However, dam removal does benefit many other riverine-dependent fish and wildlife.

- The Service recommends mitigation measures for project activities that result in the loss or alteration riparian habitat that may include: removal of any impervious surface within 100 feet of streambank and replanting with native shrub/tree species; invasive species management and replanting riparian zone with native shrub and tree species; or planting native shrub and tree species within 100 feet of streambank.

- Mitigation options that could be considered for wetland impacts should include establishment of wetlands at a 1:1 ratio and/or restoration or enhancement of existing wetlands. All of these measures must occur within the watershed. Alternatively, wetland impacts could be offset by purchase of credits through a mitigation bank.

- The 1,000 feet of river channel that would be lost due to the stream realignment proposed in Alternative 4 includes two reaches of long sweeping U-shaped meanders. Stream morphology in such meanders includes shallow areas of slow current and sediment deposition on the inside edges of the channel and deeper areas of faster current on the outside edges. This type of habitat is not present in most of the channel within the Study Area. The Service recommends that any plans for mitigating impacts to palustrine resources include strategies that increase stream habitat diversity.

- New Jersey's No Net Loss Reforestation Act (NNLRA) requires the applicant to plant one tree for every tree removed. The Service will recommend that the New Jersey Division of Land Use Regulation ensure that that full compensation be met to comply with the NNLRA. Please visit http://www.state.nj.us/dep/parksandforests/forest/community/No_Net_Loss.htm for more information.

- Consult the scientific literature and use the best available information regarding planting elevation, depth, soil type, and seasonal timing to ensure best results when revegetating sites. Include subsurface conditions such as soil and sediment geochemistry and physics, groundwater quantity and quality, and infauna when designing riparian, wetland, and instream restoration.

- Develop and implement a long-term management and monitoring plan for the alternatives. The plan should provide adequate evaluation of habitat restoration success. Information obtained will contribute to the science of in-stream and riparian habitat restoration, particularly in urban settings. The plan should include contingencies that would provide for further Corps action during post-construction monitoring, if necessary, as part of an adaptive management strategy to be implemented in coordination with affected municipalities and private landowners. Corps mitigation interventions may include regrading, re-planting, or other actions to correct for unexpected conditions, including deposition, erosion, failure of vegetation establishment, and/or re-invasion of undesirable species.

- Construction or other activities in or along waterways in the project area may impact bald eagles. Tree clearing or other disturbances to dead snags or mature timber, particularly adjacent to the Rahway River or Robinsons Branch, may affect eagles roosting or

- foraging in the area. NJDEP Landscape Project mapping shows foraging habitat for the bald eagle within the project area and a nest three miles from the project area. The Services recommends that the Corps carry out all project activities in accordance with the National Bald Eagle Management Guidelines. Please contact this office for technical assistance if the Guidelines cannot be followed; please note that pursuant to the BGEPA, a Service permit will be required if eagles will be disturbed.

- Any activities associated with a proposed alternative that could alter the hydrology of Robinsons Branch and the Ash Brook Swamp Reservation should be avoided, as such activities could result in "take" of bog turtle. Suitable habitat for bog turtle is present in this area. If any project activities are proposed for this area, a Phase Two survey should be conducted to determine the presence or absence of bog turtle, and further consultation must take place pursuant to Section 7 of the ESA.

- Proposed alternatives that include levee construction or widening of the river channel may require the removal of mature trees and shrubs from riparian corridors. These areas provide excellent foraging and roosting habitat for Indiana bat and northern long-eared bat. To avoid "take" of the Indiana bat and northern long-eared bat, the Service recommends a seasonal restriction on tree cutting and shrub removal from April 1 to September 30. If the selected alternative includes the removal of trees or shrubs within the project area, consultation must take place pursuant to Section 7 of the ESA.

- Alternatives other than *Alternative #7a: Non-Structural 10-year Plan* will likely require removing trees. The MBTA prohibits taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. Neither the MBTA nor its implementing regulations at 50 CFR Part 21 provide for permitting of "incidental take" of migratory birds. According to the New Jersey Division of Fish and Wildlife Guidance Manual for the Protection of Fish and Wildlife Resources dated July 2008, the appropriate timing restriction to protect nesting migratory birds from tree or shrub/scrub removal is March 15 to July 31. The Service recommends including seasonal restrictions into any project documents or contracts. Failure to do so may result in the illegal destruction of nests with eggs or unfledged chicks.

- Coordinate with local municipalities, non-government organizations, and land owners to promote incorporation of "green infrastructure" stormwater management systems such as residential rain barrels, rain gardens and other stormwater retention measures that increase infiltration and recharge to groundwater, and reduce peak flows of stormwater runoff.

The Service looks forward to working cooperatively with the Corps to maximize benefits to our public fish and wildlife resources from proposed activities undertaken through the Rahway River Basin Flood Risk Management Feasibility Study. Please contact Dennis Hamlin at 609-383-3938, extension 14, if you have any questions or require further assistance regarding federally listed threatened or endangered species, or migratory birds.

Sincerely,

Eric Schrading
Field Supervisor

Enclosures: 4

CC: Kelly Davis: Kelly.Davis@dep.nj.gov
Kimberly Rightler: kimberly.a.rightler@usace.army.mil

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Personal Communication

Rightler, K. Project Biologist. Email of September 18, 2014. U.S. Army Corps of Engineers, New York District. New York, New York.

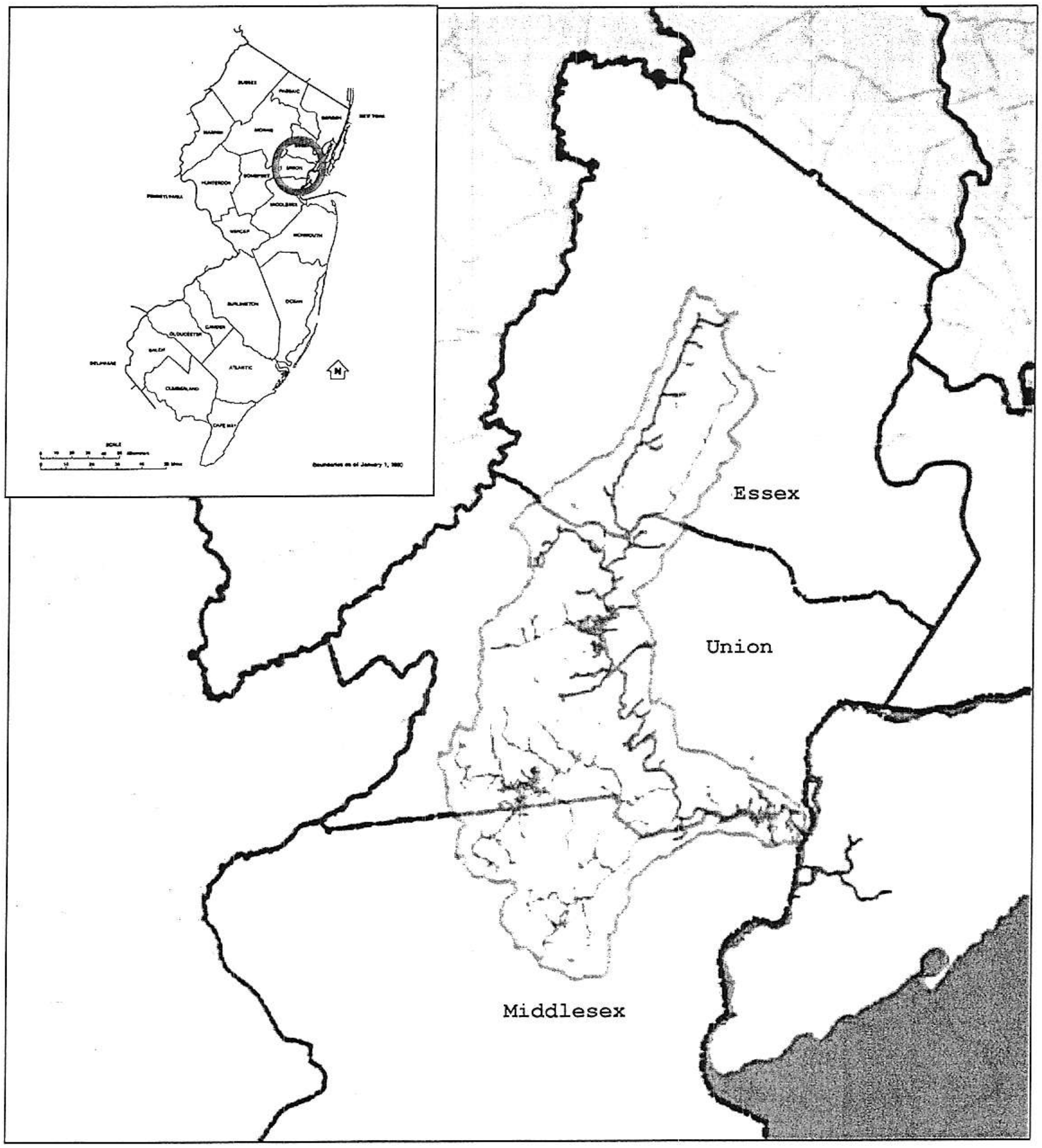

Figure 1. Rahway River Basin. Essex, Middlesex and Union Counties, New Jersey.

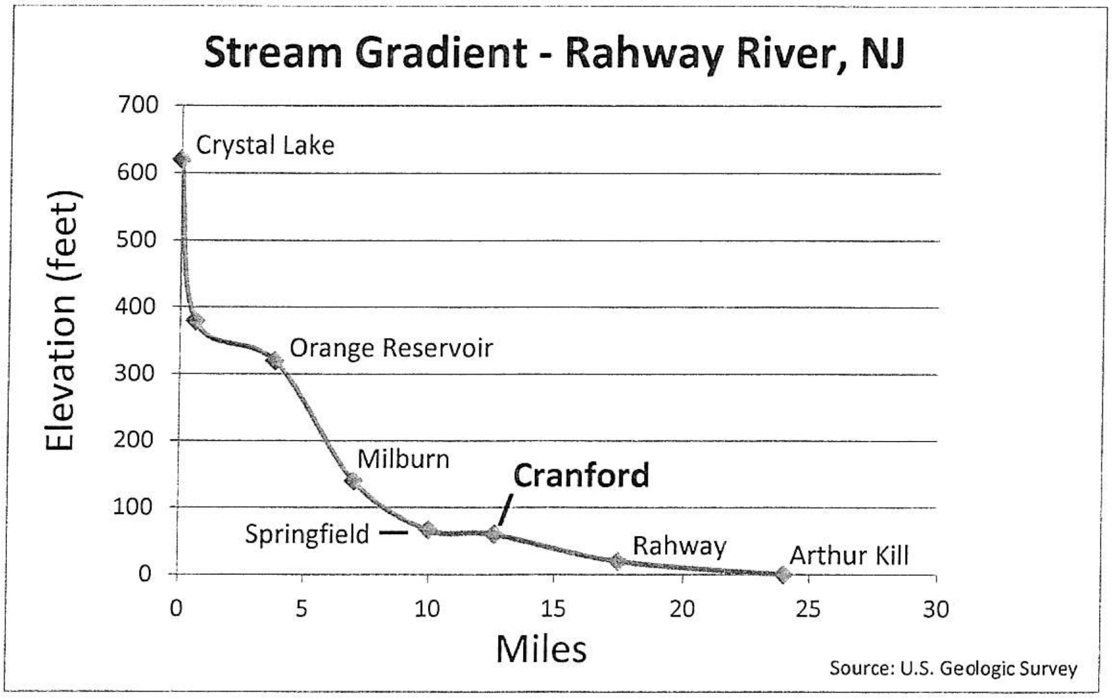

Figure 2. Stream gradient of the Rahway River from its source at Crystal Lake in Essex County to its termination at sea level in Arthur Kill (USGS 2013b, 2014a, 2014b, 2014c, 2014d).

U.S. FISH AND WILDLIFE SERVICE SPECIES NARRATIVES:
Biology and Threats of Federally Listed Species in New Jersey

Bog turtle (*Clemmys muhlenbergii*)

The bog turtle was federally listed as a threatened species in 1997.

At only about 4 inches long, the bog turtle is one of North America's smallest turtles. This species typically shows a bright yellow, orange, or red blotch on each side of the head. The nearly parallel sides of the upper shell (carapace) give bog turtles an oblong appearance when viewed from above. These small, semi-aquatic turtles consume a varied diet including insects, snails, worms, seeds, and carrion.

Bog turtles usually occur in small, discrete populations, generally occupying open-canopy, herbaceous sedge meadows and fens bordered by wooded areas. These wetlands are a mosaic of micro-habitats that include dry pockets, saturated areas, and areas that are periodically flooded. Bog turtles depend upon this diversity of micro-habitats for foraging, nesting, basking, hibernating, and sheltering. Unfragmented riparian (river) systems that are sufficiently dynamic to allow the natural creation of open habitat are needed to compensate for ecological succession. Beaver, deer, and cattle may be instrumental in maintaining the open-canopy wetlands essential for this species' survival.

Bog turtles inhabit open, unpolluted emergent and scrub/shrub wetlands such as shallow spring-fed fens, sphagnum bogs, swamps, marshy meadows, and wet pastures. These habitats are characterized by soft muddy bottoms, interspersed wet and dry pockets, vegetation dominated by low grasses and sedges, and a low volume of standing or slow-moving water which often forms a network of shallow pools and rivulets. Bog turtles prefer areas with ample sunlight, high evaporation rates, high humidity in the near-ground microclimate, and perennial saturation of portions of the ground. Eggs are often laid in elevated areas, such as the tops of tussocks. Bog turtles generally retreat into more densely vegetated areas to hibernate from mid-September through mid-April.

The greatest threats to the bog turtle are the loss, degradation, and fragmentation of its habitat from wetland alteration, development, pollution, invasive species, and natural vegetational succession. The species is also threatened by collection for illegal wildlife trade.

U.S. FISH AND WILDLIFE SERVICE SPECIES NARRATIVES:
Biology and Threats of Federally Listed Species in New Jersey

Indiana bat (*Myotis sodalis*)

The Indiana bat was federally listed in 1967 and classified as an endangered species in 1973.

The Indiana bat is a small, brown mammal about 1.5 to 2 inches long. This species closely resembles the little brown bat, from which it can be distinguished by small differences in fur coloration and the structure of the feet. As with all eastern U.S. bat species, Indiana bats feed almost exclusively on insects.

Each fall from late August through October, Indiana bats migrate from their summer habitats to congregate in the vicinity of their hibernation sites, which include caves and abandoned mine shafts. During this time, the bats engage in mating activity and feed in the surrounding area to build the fat reserves needed during hibernation. The bats then hibernate from late October to April, the precise timing dependent on climatic conditions. After emerging from hibernation, Indiana bats forage in the vicinity of the hibernation site before migrating to summer habitats. Studies indicate that Indiana bats typically forage within 10 miles of hibernacula before and after hibernation.

When not hibernating, Indiana bats roost under loose tree bark by day, and forage for flying insects in and around the tree canopy at night. A variety of upland and wetland habitats are used as foraging areas, including flood plain, riparian (along rivers), and upland forests; pastures; clearings with early successional vegetation; cropland borders; and wooded fencerows. Preferred foraging areas are streams, associated flood plain forests, and impounded bodies of water such as ponds and reservoirs.

During the summer months, numerous female bats roost together in maternity colonies under the loose bark of dead or dying trees within riparian, flood plain, and upland forests. Maternity colonies use multiple roosts in both living and dead trees. Female Indiana bats raise a single offspring each year. Adult males usually roost in trees near maternity roosts, but some males remain near the hibernaculum and have been found in caves and mines during the summer.

Protection of Indiana bats during all phases of their annual life cycle is essential to preserving this species. Threats to the Indiana bat include disturbance or killing of hibernating and maternity colonies; vandalism and improper closure of hibernacula; fragmentation, degradation, and destruction of forested summer habitats; and use of pesticides and other environmental contaminants. In recent years, White Nose Syndrome has also emerged as a major threat to the Indiana bat and many other bat species.

January 12, 2015

U.S. FISH AND WILDLIFE SERVICE SPECIES NARRATIVES: Biology and Threats of Federal Proposed Species in New Jersey

Under Section 7(a)(4) of the Endangered Species Act, a Federal agency must confer with the U.S. Fish and Wildlife Service on any agency action that is likely to jeopardize the continued existence of any species that the Service has proposed to be listed, or that is likely to result in the destruction or adverse modification of critical habitat proposed to be designated for such species.

Northern Long-Eared Bat (*Myotis septentrionalis*)

The northern long-eared bat (*Myotis septentrionalis*) is a medium sized bat weighing approximately 5 to 8 grams with females slightly larger than males. The northern long-eared bat is distinguished from other *Myotis* species by its long ears.

The northern long-eared bat overwinters in caves and abandoned mines. Hibernacula are typically large with constant temperatures, high humidity and no air currents. Within hibernacula, northern long-eared bats are found in tight crevices and cracks with only nose and ears visible. The northern long-eared bat congregates in the vicinity of their hibernacula in August or September and enters into hibernation in October and November. The bat shows a high degree of philopatry (using the same site multiple years) to hibernaculum, although they may not return to the same hibernaculum in successive years. Movement between hibernacula throughout the winter has also been observed. There are eight known hibernacula in Northern New Jersey.

In April northern long-eared bats emerge from hibernation and migrate to summer habitat. Migratory movements are short compared to the Indiana bat, with movement typically between 35 miles and 55 miles. Once at summer habitat, the northern long-eared bat is comparable to the Indiana bat in terms of summer roost selection, but appears to be more opportunistic. Northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Maternity colonies generally consist of 30 to 60 individuals. Males and non-reproductive females may roost in cooler places, like caves and mines. Roosting northern long-eared bats have also been observed in humanmade structures, such as buildings, barns, sheds, cabins, under eaves of buildings, and in bat houses. In southern New Jersey the northern long-eared bat is known to roost in Atlantic white cedar.

Preferred foraging areas are in forested habitats. The northern long-eared bat emerges at dusk and feeds on moths, flies, leafhoppers, caddisflies, and beetles approximately 3 to 10 feet above the ground. Gleaning arachnids and other insects from foliage is also a foraging technique used by northern long-eared bats.

The distribution of the northern long-eared bat includes the Midwest and Northeast of the United States, and all Canadian provinces west to the southern Yukon Territory and Eastern British Columbia. In New Jersey, the northern long-eared bat is found statewide.

January 12, 2015

U.S. FISH AND WILDLIFE SERVICE SPECIES NARRATIVES:
Biology and Threats of Federally Delisted Species in New Jersey

Bald eagle (*Haliaeetus leucocephalus*)

The bald eagle was federally listed in 1967, and classified as an endangered species in 1973. With increasing numbers, bald eagle populations in the coterminous 48 States were re-classified from endangered to threatened in 1995, and delisted on August 9, 2007. The bald eagle continues to be protected under Federal laws including the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The bald eagle also remains a State-listed species under the New Jersey Endangered and Nongame Species Conservation Act, which carries protections under the State land use regulation program. These Federal and State laws prohibit unauthorized take of bald eagles. For the continued protection of bald eagles, and to ensure compliance with Federal and State laws, the U.S. Fish and Wildlife Service (Service) recommends managing bald eagles in accordance with the National Bald Eagle Management Guidelines and all applicable State regulations. The Service and its partners are monitoring the bald eagle for a 20 year period to ensure populations remain stable following delisting.

With a wingspan that can exceed 7 feet, the bald eagle is the second largest bird of prey in North America. The bald eagle is our National symbol and unmistakable in appearance, featuring a white head and tail that contrast with a dark body. Juvenile birds lack the white head and tail, and are mottled in appearance until their fifth year. Eagles are opportunistic feeders and will eat carrion or live prey, primarily fish, but also small mammals, reptiles, and waterfowl.

Bald eagles occur in New Jersey throughout the year. The breeding season in New Jersey begins in late December to early January. During this period, mating pairs will work diligently to build or repair their nest. First-year nests can measure 2 feet high and 5 feet across. Eagles may use the same nest year to year, adding sticks and other nesting material, making the nest larger and larger each year. By the middle of February, most bald eagles in New Jersey have begun to lay their clutch of one to three eggs. Young eagles learn to fly (fledge) 11 to 12 weeks after hatching. Adults continue to provide food for the juvenile eagles for as long as 3 months after they fledge. During this period, the fledglings learn to fly proficiently and begin to hunt for themselves.

Bald eagles prefer forested or open habitats with little human disturbance near large bodies of water, such as lakes, large rivers, reservoirs, and bays. Eagles are often attracted to a water body as they search for food, and frequently roost in dead or mature trees adjacent to water. In winter, bald eagles gather in large numbers near coasts and inland water bodies that remain ice-free, allowing access to fish and other prey.

Threats to the bald eagle include environmental contaminants, habitat destruction and degradation, and disturbance of nesting and feeding birds.

January 12, 2015

From: Markuson, Jeremy
To: Rightler, Kimberly A NAN02
Subject: Re: [EXTERNAL] Re: ESA Coordination for Indiana bat and Northern Long-Eared Bat
Date: Friday, December 18, 2015 9:03:06 AM

Got it!

I think this would qualify as a linear project. When I calculated the total distance shown on the map I came up with 3.6 km. So, I would say let's try to get at minimum of 20 net nights completed. After looking at aerials I agree that some effort may need to focus on the travel corridors near the river and tribs. Focusing in some of these areas probably provide the greatest success of capturing bats while they are foraging for prey.

Cheers,

Jeremy

Please Note Our New Address!

Jeremy Markuson
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Unit 4
Galloway, New Jersey 08205-4465
Phone: 609-382-5266
Fax: 609-646-0352

On Thu, Dec 17, 2015 at 7:02 PM, Rightler, Kimberly A NAN02 <Kimberly.A.Rightler@usace.army.mil <mailto:Kimberly.A.Rightler@usace.army.mil> > wrote:

Hi Jeremy,

Yes, the clearing would occur within the yellow portions of the dam embankment. There is also a floodwall in the northeast corner that would be modified and we were told that would also have to have the 50 ft zone because it also acts as a dam. It's hard to see in the wetland map, so I placed a note indicating it's location.

Not that I'm a bat expert, but I would anticipate some nets being set up along the embankment, down within the proposed 50 ft zone and then just outside the 50 ft zone close to the river and tribs. Feel free to correct my assumptions.

Thanks,
Kim

-----Original Message-----
From: Markuson, Jeremy [mailto:jeremy_markuson@fws.gov <mailto:jeremy_markuson@fws.gov>]
Sent: Thursday, December 17, 2015 4:54 PM
To: Rightler, Kimberly A NAN02 <Kimberly.A.Rightler@usace.army.mil <mailto:Kimberly.A.Rightler@usace.army.mil> >
Subject: Re: [EXTERNAL] Re: ESA Coordination for Indiana bat and Northern Long-Eared Bat

Hi Kim,

Is the tree clearing going to be restricted to the yellow portions of the dam embankment map (RahwayFluvial_LenapeDamEmbankment_Wetlands.pdf) or does the 32 acres also include other clearing activities?

Thanks,

Jeremy

Please Note Our New Address!

Jeremy Markuson
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Unit 4
Galloway, New Jersey 08205-4465
Phone: 609-382-5266
Fax: 609-646-0352

From: Rightler, Kimberly A NAN02
To: "Markuson, Jeremy"
Subject: RE: [EXTERNAL] Re: ESA Coordination for Indiana bat and Northern Long-Eared Bat
Date: Thursday, December 17, 2015 12:33:00 PM

Hi Jeremy,

Thanks for the information. Good to see Jon Chenger is on the list; he's the one who conducted the survey for Green Brook Segment B1 several years ago.

We're not going to mess around with the acoustic survey, we'll just go straight to mist netting which leads me to a question. Would you consider this a linear project? The embankments are linear, but with the amount of trees, the river and the multiple small tribs within the park, I'm thinking that the needed net nights would be closer to non-linear minimum of 42 net nights. I'm trying to develop a rough estimate for the cost of the survey so we can get a sense of how much this will be.

Also, I was so focused on bats, I forgot to ask whether you feel there are any other Fed E&T species that we should be concerned about within this area. The IPAC website didn't note any, just the bats.

Thanks and you have a Merry Christmas as well!
Kim

From:	Markuson, Jeremy
To:	Rightler, Kimberly A NAN02; Brighton, Nancy J NAN02
Subject:	Re: [EXTERNAL] Re: ESA Coordination for Indiana bat and Northern Long-Eared Bat
Date:	Thursday, December 17, 2015 10:07:49 AM
Attachments:	NJ_MYSO_MYSE_Surveyors_List July 9_2015.pdf

It was nice speaking with you Kim and Nancy. Attached is a list of qualified Indiana bat/northern long-eared bat surveyors. The summer survey season I'd recommend is June 1 through August 15. Also, here is the current survey protocols: Blockedhttp://www.fws.gov/midwest/Endangered/mammals/inba/inbasummersurveyguidance.html. Although I didn't mention it on the phone, you can choose to conduct acoustic surveys or mist net surveys to determine presence or absence. Because acoustic surveys can at times provide results that are difficult to analyze and interpret, I'd suggest the mist netting option rather than acoustic. Mist netting can also be beneficial because if you capture federally listed species a radio transmitter will be immediately placed on the bat and tracking activities will begin. However, if you choose to do acoustics and detect (or if there is a probable detection) of federally listed bats the next steps I'd recommend is try and capture the bats by mist netting and then tracking. Rather than do an extra step, if federally listed bats are detected using acoustic bat detectors, I'd suggest going straight to mist netting. The only downside with mist netting is that it's more costly and takes more time to complete. Anyhow, once you choose the bat surveyor and the survey methodology, please provide me a summer bat survey work plan that I can review and approve.

Thanks and have a Merry Christmas!

Jeremy

Please Note Our New Address!

Jeremy Markuson
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Unit 4
Galloway, New Jersey 08205-4465
Phone: 609-382-5266
Fax: 609-646-0352

From:	Rightler, Kimberly A NAN02
To:	"Markuson, Jeremy"
Cc:	"Popowski, Ron"; Brighton, Nancy J NAN02; "Hamlin, Dennis"
Subject:	ESA Coordination for Indiana bat and Northern Long-Eared Bat
Date:	Wednesday, December 09, 2015 2:00:00 PM

Hi Jeremy,

I hope you had a nice Thanksgiving and a successful office relocation. I have another project that I would like to coordinate with you on regarding the Subject species. The New York District is currently conducting a Feasibility Study to determine Federal interest in implementing flood risk management measures within the Rahway River Basin.

Two of the flood risk management alternatives we are evaluating include increasing the height of existing embankments at Lenape Park, located in Cranford Township, Union County (refer to attachments 1, 2 and 3). I would like to note that this is a dry dam and would remain a dry dam under our alternatives.
For dams (dry and wet), the Corps has a policy requiring the maintenance of a vegetation management zone comprised of maintained lawn only (no trees/no shrubs) from a minimum of 50 ft outward from the embankment toe.

For a dry dam, such as the Lenape Park Dam, this would be required on both sides. Through coordination with our Headquarters and Dam Safety Center of Expertise, this minimum 50 ft vegetation management zone is strictly enforced. Therefore, we have estimated that approximately 32 acres of forest could be removed as a result of increasing the footprint of the existing embankments and creating the 50 ft zone on either side.

In looking at the list of NJ Municipalities with Hibernation or Maternity Occurrence of Indiana bat or northern long eared bat (4th attachment), Cranford is within eight miles of multiple municipalities having maternity colonies of one or both species (e.g. Millburn, Summit, Berkeley Heights, etc.).

The team is currently evaluating how this vegetation requirement effects the costs and feasibility of implementing these alternatives. As part of this evaluation, I would appreciate your feedback on whether you feel the amount of acreage impacted raises us to a level where we may need to conduct presence/absence surveys or the preparation of a biological assessment.

Dennis had prepared a Planning Aid Letter (5th attachment) back in February of this year for this study, but the two alternatives that include Lenape Park were formulated subsequent of the PAL was submission so it doesn't include a full evaluation of impacts/recommendations in regards to clearing in Lenape Park.

It may be beneficial to have a call to discuss this further. If you could let me know when you may be available for a call, I would appreciate it.

Thank you,
Kim

Rahway River Basin, New Jersey

Flood Risk Management Feasibility Study

APPENDIX A5

Cultural Resources

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 14, 2016

Reply to Attention of

Environmental Assessment Section
Environmental Analysis Branch

Ms. Katherine Marcopul
Deputy State Historic Preservation Officer
State of New Jersey Department of Environmental Protection
Historic Preservation Office
PO Box 420
Trenton, NJ 08625-0420

REF: HPO K-2012-106
13-0094-1

Dear Ms. Marcopul:

The U.S. Army Corps of Engineers, New York District (District) is concluding the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. The reports were submitted to your office for review and comment at the time of their completion.

In May of this year the District met with your staff to review the Tentatively Selected Plan (TSP) and to discuss its intent to draft and execute a Programmatic Agreement (PA). To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. The PAs outline the steps required to carry out the District's remaining Section 106 responsibilities including conducting additional surveys, consultation with interested parties, determining adverse effects, and, if necessary, mitigation for adverse effects. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure).

I would like to take this opportunity to invite the New Jersey State Historic Preservation Office to comment upon the draft PAs for the Rahway River Fluvial Flood Risk Reduction

Project. The PAs will be entered into at a minimum by the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. The Advisory Council is also invited to be a signatory to both PAs as well as a number of Tribes who have extensive cultural heritage in the region. These are the Delaware Nation, the Shawnee Tribe of Oklahoma, and the Delaware Tribe of Indians. Finally, several historical societies have been invited to participate as concurring parties to the PAs due to their heavy involvement in preservation in the area. These are the Cranford Historic Preservation Advisory Board, the Merchants and Drovers Tavern Museum Association, and the West Orange Historic Preservation Commission. Should there be any other groups who your office feels should participate in this process please include that information with your comments.

Please review the enclosed preliminary case report and draft PA and provide any comments within 30 days of your receipt of this letter. If you feel it would be beneficial to schedule a meeting or conference call amongst the consulting parties, please include that with your comments. We look forward to working with you on the Rahway River Fluvial Flood Risk Management Project.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Mr. Reid Nelson, Director
Office of Federal Agency Programs
Advisory Council on Historic Preservation
401 F Street NW, Suite 308
Washington, DC 20001-2637

Dear Mr. Nelson:

The U.S. Army Corps of Engineers, New York District (District) is concluding the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. The reports were submitted to the New Jersey State Historic Preservation Office (NJSHPO) and other interested parties for review and comment at the time of their completion.

In May of this year the District met with the NJSHPO to review the Tentatively Selected Plan (TSP) and to discuss its intent to draft and execute a Programmatic Agreement (PA). To simplify coordination moving forward, two PAs have been prepared for the project, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. The PAs outline the steps required to carry out the District's remaining Section 106 responsibilities including conducting additional surveys, consultation with participating parties, determining adverse effects, and, if necessary, mitigation for adverse effects. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure).

I would like to take this opportunity to invite the Advisory Council on Historic Preservation to comment upon the draft PAs for the Rahway River Fluvial Flood Risk Management Project. In addition to the ACHP, a number of Tribes who have extensive cultural heritage in the region are invited to participate in the PAs as signatories as well. These are the Delaware Nation, the Shawnee Tribe of Oklahoma, and the Delaware Tribe of Indians.

Additionally, several historical societies have been invited to participate as concurring parties to the PAs due to their heavy involvement in preservation in the area. These are the Cranford Historic Preservation Advisory Board, the Cranford Historical Society, the Merchants and Drovers Tavern Museum Association, and the West Orange Historic Preservation Commission.

We invite you to consult with us on the Rahway River Fluvial Flood Risk Management Project and participate in the PAs as per 36 CFR Part 800.6. If you or your staff require additional information or have any questions, please contact Carissa Scarpa, Project Archaeologist, at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosures

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Cranford Historical Society
Hanson House Annex
38 Springfield Ave.
Cranford, NJ 07016

To Whom It May Concern:

The U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A digital copy of all three reports are enclosed for your records (Enclosure 1).

Recently the District identified a Tentatively Selected Plan (TSP) for the project. The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. To address potential impacts to historic properties, a Programmatic Agreement (PA) has been prepared that outlines the steps the District will take to carry out its remaining Section 106 responsibilities including conducting additional surveys, consultation with interested parties, determining adverse effects, and, if necessary, mitigation for adverse effects. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a party with significant interest in the preservation of historic resources in the Cranford Section of the project area, I would like to take this opportunity to invite the Cranford Historical Society to comment upon the draft PA for the Rahway River Fluvial Flood Risk Reduction Project, Cranford Section, and to act as a concurring party to the PA. The PA, at a minimum, is to be entered into by the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. The Advisory Council is also invited to participate as well as a number of Federally Recognized Tribes who have extensive cultural heritage in the region. These are the Delaware Nation, the Shawnee Tribe of Oklahoma, and the Delaware Tribe of Indians. The North Cranford Historic Preservation Advisory Board and the West Orange Historic Preservation Commission have been invited to participate as concurring parties as well. Should there be any other groups who your organization feels should participate in this process please include that information with your comments.

Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If your organization requires additional information or feels it would be beneficial to schedule a meeting or conference call to discuss the terms of the agreement, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Ms. Maureen Strazdon
Chair, Cranford Historic Preservation Advisory Board
208 Holly Street
Cranford, NJ 07016

Dear Ms. Strazdon:

As you know, the U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A copy of the Phase IA survey was provided to the Cranford Historic Preservation Advisory Board (Board) for review in 2013. A digital copy of all three reports are enclosed for your records (Enclosure 1).

The District met with the Board in May of this year when the Tentatively Selected Plan (TSP) was identified to discuss potential impacts to historic properties and the development of a Programmatic Agreement (PA) that would outline the steps the District will take to carry out the its remaining Section 106 responsibilities including conducting additional surveys, consultation with interested parties, determining adverse effects, and, if necessary, mitigation for adverse effects. As you know there are two areas that have been part of the ongoing study, the Cranford Section and the Robinson's Branch Section. The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a party with significant interest in the preservation of historic resources in the Cranford Section of the project area I would like to take this opportunity to invite the Board to comment upon the draft PA for the Rahway River Fluvial Flood Risk Reduction Project, Cranford Section, and to act as a concurring party to the PA. At a minimum, the PA is to be entered into by the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. The Advisory Council is also invited to participate as well as a number of Federally Recognized Tribes who have significant cultural heritage in the region. These are the Delaware Nation, the Shawnee Tribe of Oklahoma, and the Delaware Tribe of Indians. The West Orange Historic Preservation Commission and the Cranford Historical Society have been invited to participate as concurring parties as well. Should there be any other groups who your office feels should participate in this process please include that information with your comments.

Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If the Board requires additional information or feels it would be beneficial to schedule a meeting to discuss the terms of the agreement, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Ms. Nekole Alligood
Cultural Preservation Director
Delaware Nation
P.O. Box 825
Anadarko, OK 73005

Dear Mr. Ross:

The U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A copy of those reports are enclosed for your records (Enclosure 1).

The study is progressing and a Tentatively Selected Plan (TSP) has recently been identified. The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. Due to the fact that the details of the plan are not finalized at this time and additional investigations are required the District has elected to develop a Programmatic Agreement (PA) for the project. A PA outlines the steps required to carry out the District's remaining Section 106 responsibilities including conducting additional surveys, consultation with interested parties, determining adverse effects, and, if necessary, mitigation for adverse effects. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a tribe with significant cultural heritage in the region, I would like to invite you to review and comment upon the draft PAs for the Rahway River Fluvial Flood Risk Management Feasibility Study. At a minimum the PAs are intended to be entered into by the U.S. Army

Corps of Engineers and the New Jersey State Historic Preservation Office. We also would like invite the Delaware Nation to participate in the PAs as a signatory, or if signatory is not preferred, as a concurring party which would provide the Delaware Nation with the opportunity to consult on the project and receive status updates as it proceeds. Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If you feel it would be beneficial to schedule a meeting or conference call amongst the consulting parties, please include that with your comments. If you or your staff require additional information or have any questions, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
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NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Ms. Susan Bachor
Delaware Tribe
Historic Preservation Representative
P.P. Box 64
Pocono Lake, PA 18347

Dear Ms. Bachor:

The U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A copy of those reports are enclosed for your records (Enclosure 1).

The study is progressing and a Tentatively Selected Plan (TSP) has recently been identified. The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. Because the details of the plan are not finalized at this time and additional investigations are required the District has elected to develop a Programmatic Agreement (PA) for the project that would outline the steps required to carry out the District's remaining Section 106 responsibilities including conducting additional surveys, consultation with participating parties, determining adverse effects, and, if necessary, mitigation for adverse effects. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a tribe with significant cultural heritage in the region, I would like to invite you to review and comment upon the draft PAs for the Rahway River Fluvial Flood Risk Management Feasibility Study. At a minimum, the PAs are intended to be entered into by the U.S. Army

Corps of Engineers and the New Jersey State Historic Preservation Office. We would also like invite the Delaware Tribe to participate in the PAs as a signatory, or if signatory is not preferred, as a concurring party which would provide the Delaware Tribe with the opportunity to consult on the project and receive status updates as it proceeds. Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If you feel it would be beneficial to schedule a meeting or conference call amongst the consulting parties, please include that with your comments. If you or your staff require additional information or have any questions, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
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NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Mr. Alex Shipley
Director of Museum Operations
Merchants and Drovers Tavern Museum Association
P.O. Box 1842
1632 St. George Avenue
Rahway, NJ 07065

Dear Mr. Shipley:

The U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A digital copy of all three reports are enclosed for your records (Enclosure 1).

Recently the District identified the Tentatively Selected Plan (TSP). The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. To address potential impacts to historic properties a Programmatic Agreement (PA) has been prepared that would outline the steps the District will take to carry out its remaining Section 106 responsibilities including conducting additional surveys, consultation with interested parties, determining adverse effects, and, if necessary, mitigation for adverse effects. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a party with significant interest in the preservation of historic resources in the Robinson's Branch Section of the project area I would like to take this opportunity to invite the

Merchants and Drovers Tavern Museum Association to comment upon the draft PA for the Rahway River Fluvial Flood Risk Reduction Project, Robinson's Branch Section, and to act as a concurring party on the PA. At a minimum, the PA is to be entered into by the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. The Advisory Council is also invited to participate as well as a number of Federally Recognized Tribes who have extensive cultural heritage in the region. These are the Delaware Nation, the Shawnee Tribe of Oklahoma, and the Delaware Tribe of Indians. Should there be any other groups who your organization feels should participate in this process please include that information with your comments.

Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If the Association requires additional information or feels it would be beneficial to schedule a meeting or a conference call to discuss the terms of the agreement, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

October 26, 2016

Reply to the Attention of

Environmental Assessment Section
Environmental Analysis Branch

Ms. Kim Jumper
Tribal Historic Preservation Officer
Shawnee Tribe of Oklahoma
29S HWY69A
Miami, OK 74355

Dear Ms. Jumper:

The U.S. Army Corps of Engineers, New York District (District) is undertaking the Rahway River Fluvial Flood Risk Management Feasibility Study. In recent years the District prepared a series of survey reports titled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project,* and *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam.* The surveys were carried out in accordance with Section 106 of the National Historic Preservation Act, as amended, and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800) to identify significant historic properties in the study area. A copy of those reports are enclosed for your records (Enclosure 1).

The study is progressing and a Tentatively Selected Plan (TSP) has recently been identified. The TSP for the Cranford Section of the project consists of channelization along the Rahway River in Cranford, New Jersey, and modifications to the Orange Reservoir and Dam in West Orange, New Jersey. The TSP for the Robinson's Branch Section of the project consists of non-structural flood proofing measures in the City of Rahway, New Jersey. Due to the fact that the details of the plan are not finalized at this time and additional investigations are required the District has elected to develop a Programmatic Agreement (PA) for the project that would outline the steps required to carry out the District's remaining Section 106 responsibilities including conducting additional surveys, consultation with participating parties, determining adverse effects, and, if necessary, mitigation for adverse effects. To simplify coordination moving forward, two PAs have been prepared, one that addresses the plan for flood risk management measures in the Cranford Section of the project area and another that addresses the measures planned for the Robinson's Branch Section of the project area. A preliminary case report has been prepared that includes a summary of the cultural resources work undertaken to date, agency coordination letters, the draft PAs, and project maps along with other relevant project information (Enclosure 2).

As a tribe with significant cultural heritage in the region, I would like to invite you to review and comment upon the draft PAs for the Rahway River Fluvial Flood Risk Management

Feasibility Study. The PAs are intended to be entered into by the U.S. Army Corps of Engineers and the New Jersey State Historic Preservation Office. We also would like invite the Shawnee Tribe to participate in the PAs as a signatory, or if signatory is not preferred, as a concurring party which would provide your Tribe with the opportunity to consult on the project and receive status updates as it proceeds. Please provide a written response within 30 days to the project archaeologist, Ms. Carissa Scarpa by mail (US Army Corps of Engineers, CENAN-PL-EA, 26 Federal Plaza, Room 2131, New York, NY 10278) or by email to Carissa.a.scarpa@usace.army.mil. If you feel it would be beneficial to schedule a meeting or conference call amongst the consulting parties, please include that with your comments. If you or your staff require additional information or have any questions, please contact Ms. Scarpa at (917) 790-8612.

Sincerely,

Peter M. Weppler
Chief, Environmental Analysis Branch

Enclosure

U.S. Army Corps of Engineers
New York District

Cultural Resources Summary and Preliminary Case Report

Rahway River Fluvial Flood Risk Management Project

Prepared by
U.S. Army Corps of Engineers
New York District
Planning Division
26 Federal Plaza,
New York, NY 10278-0090

DRAFT
October 2016

Carissa Scarpa
Project Archaeologist

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Appendices

I. Introduction

The US Army Corps of Engineers, New York District (District) has undertaken a feasibility study designed to identify flood risk management measures that would reduce the incidence and severity of flooding in the Rahway River Basin. The study was authorized by Section 204 of the Flood Control Act of 1965 (P.L. 89-298) and U.S. House of Representatives Resolution Docket 2548, adopted March 1998. At the beginning of the feasibility study, an assessment of the entire Basin took place for the purpose of identifying all flood risk management problems and opportunities in the Rahway River Basin. The Initial Screening Report recommended further investigation in the Township of Cranford and the City of Rahway along the Robinson's Branch, two areas within the basin that experienced regular flooding for past storm events. Due to this initial screening, and through coordination with New Jersey Department of Environment Protection (NJDEP), the non-Federal sponsor, and local stakeholders, the main focus of the ongoing study has been on fluvial flooding within Cranford and Rahway. The U.S. Army Corps of Engineers Headquarters (HQ) and Major Subordinate Command (MSC) have indicated that tidal flooding within the lower portion of the Rahway River Basin is to be investigated in a separate coastal storm risk management study. The tidal portion of the Rahway River is called the Rahway River Tidal Flood Risk Management Project.

After Tropical Storm Irene in August 2011 local stakeholders requested that the District investigate potential flood storage opportunities outside/upstream of the Township of Cranford that would benefit not only Cranford but other municipalities as well. Two of the areas analyzed for storage were the existing Orange Reservoir in West Orange and a proposed dry detention basin in South Mountain Reservation along the West Branch of Rahway River.

During preliminary analysis, the District evaluated a number of alternatives to address flooding in Cranford and the expanded study area:

Alternative 1: Channel work from Lenape Dam to Lincoln Ave. Bridge, and modification to Lenape Park Detention Dam.
Alternative 2: Channel work from Springfield Ave. Bridge to Lincoln Ave. Bridge, and modification to the Nomahegan levees and Lenape Park Detention Dam.
Alternative 3: Channel work from Lenape Dam to Lincoln Ave. Bridge and dredging Orange Reservoir to increase storage capacity.
Alternative 4: Channel work from Lenape Dam to Lincoln Ave. Bridge and new outlet at Orange Reservoir for channel flow increase mitigation.
Alternative 4a: Channel work from below Nomahegan Park to below South Avenue Bridge in Cranford and new outlet at Orange Reservoir.
Alternative 5: Channel work from Lenape Dam to Lincoln Ave. Bridge and the construction of South Mountain Regional Detention Basin.
Alternative 5a: Channel work from Lenape Dam to Lincoln Ave. Bridge, the construction of South Mountain Regional Detention Basin and the relocation of Brookside Drive.
Alternative 6: South Mountain Regional Detention Basin at South Mountain Reservation.
Alternative 6a: South Mountain Regional Detention Basin with the relocation of Brookside Drive.
Alternative 7: Nonstructural Plans with a 1% and 10% chance of annual exceedance along the Rahway River at Cranford.

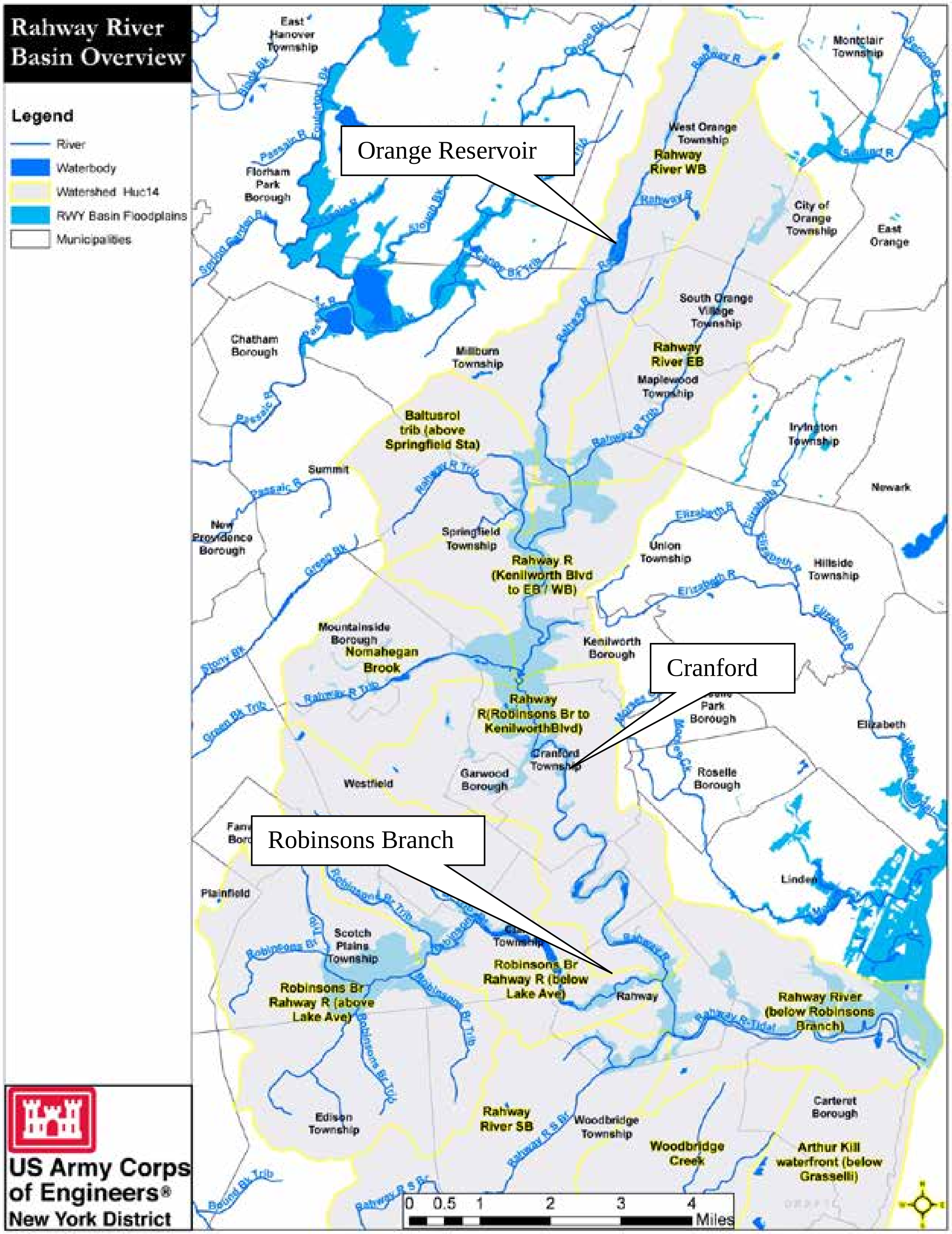


Figure 1: Rahway River Basin Overview

Alternative 8: Modification to Lenape Park Detention Dam and New Outlet at Orange Reservoir.
Alternative 9: Modification to Lenape Park Detention Dam, New Outlet at Orange Reservoir and Channel Modifications from Springfield Ave. Bridge to Lincoln Ave. Bridge in Cranford.

The District evaluated three alternatives for the Robinson's Branch Section:

Alternative 1: Combination of Levees/Floodwalls and Channel Modification.
Alternatives 2a & b: Nonstructural Plans with a 1% and 10% chance of annual exceedance along Robinson's Branch and Rahway River at Clark.
Alternative 3: Modification of Robinson's Branch Dam (Middlesex Reservoir).

II. Cultural Resources Investigations

In 2013 and 2016 cultural resources investigations were carried out for the Cranford and Robinson's Branch study areas to identify historic properties and areas of archaeological sensitivity.

Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union, and Westfield and Borough of Kennilworth, Union County, New Jersey. Panamerican Consultants, Inc. 2013.

A Phase IA cultural resources investigation was carried out in 2013 that addressed alternatives 1 and 2, as well as portions of alternatives 3 through 9. The plan features that were evaluated included major and minor modification to the Rahway River channel and bridges, flood walls, levees, and construction of detention basins in Lenape Park and Nomahegan Park (Figure 2). The survey consisted of a review of previous research, historic maps, and relevant National Register of Historic Places (NRHP) nomination forms and data on file at the New Jersey Historic Preservation Office (NJSHPO). An archaeological sensitivity assessment and architectural inventory were also carried out as part of the survey. The investigation of the Orange Reservoir and South Mountain Detention Basin were not part of the survey.

A total of 124 individual architectural resources were recorded within the Area of Potential Effect (APE) in the Townships of Springfield, Union, and Cranford, and the Borough of Kenilworth, Union County, New Jersey, with the majority of the resources located in Cranford. Each of the historic resources were photographed and subjected to a preliminary assessment. Four National Register-eligible (NRE) historic districts are located within the APE: the North Cranford Historic District (Identification [ID] #3838); the Central Railroad of New Jersey (CNJ) Main Line Corridor Historic District (ID #3500); the Rahway River Parkway Historic District (ID #4079); and the Union County Park System Historic District (ID #4424). Several of these historic districts overlap each other and the individually eligible Rahway River Parkway Historic District is contained within the Union County Park System Historic District. One property within the APE is individually listed on the National Register: Droescher's Mill (NR #7400192) at 347 Lincoln Avenue, Cranford, at the southern-most point of the APE. An architectural survey was recommended to evaluate many of the historic resources identified and to address the boundaries of historic districts and individual contributing elements for independent eligibility for the NRHP.

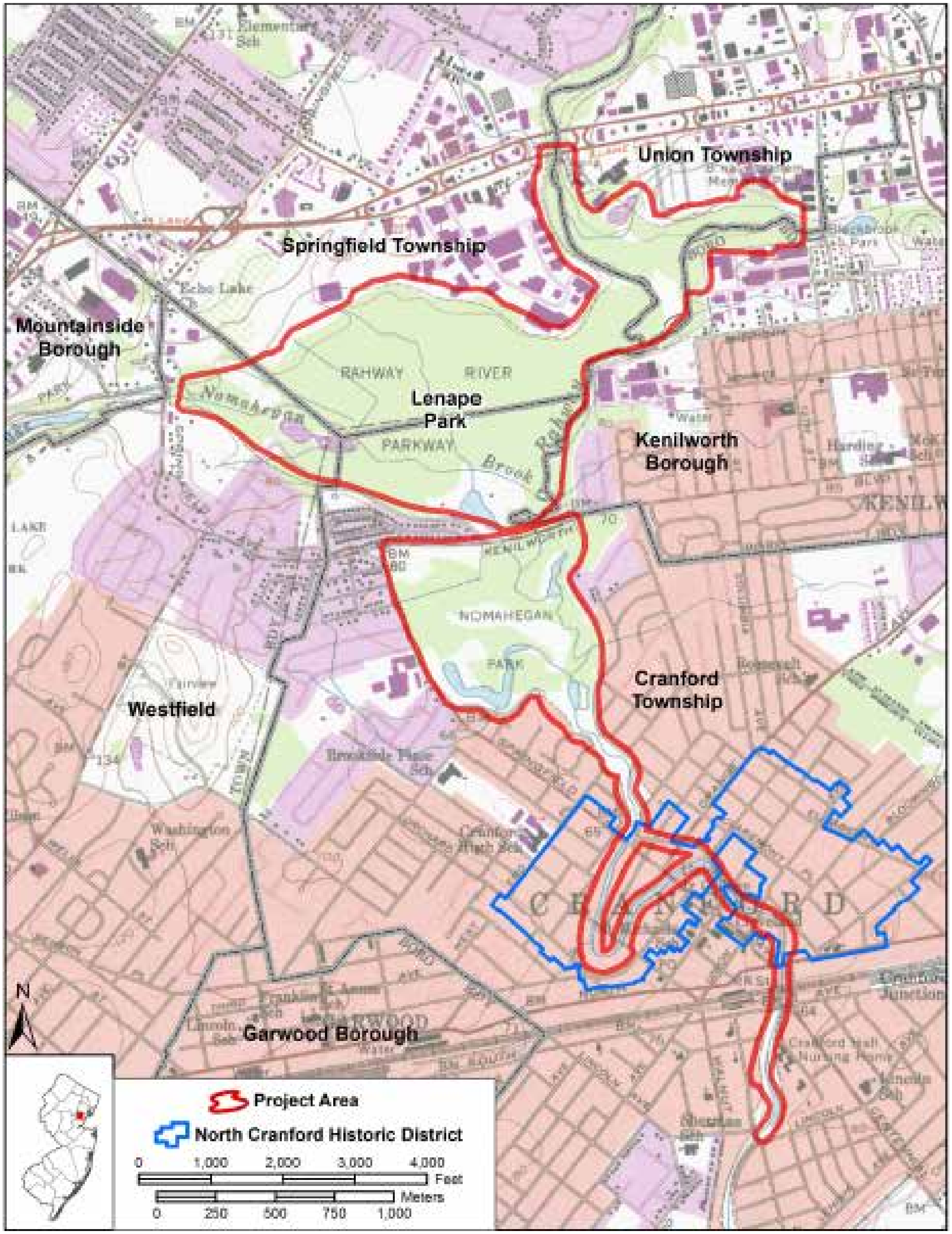


Figure 2: Phase IA Cranford Study Area

An archaeological sensitivity assessment was carried out for the study area consisting of historic map analysis, review of archaeological contexts for Union County, review of known archaeological sites in the area and surface reconnaissance in the study area. Nearly all of the study area was considered sensitive for historic and prehistoric archaeological resources. Pending selection of a design alternative, shovel testing was recommended for all areas where the project will have below-ground impacts. Deep testing strategies were recommended for areas where the ground surface has been artificially elevated with the understanding that some fill, having been added for construction of historic homes along the River, may also contain historic materials.

Phase I Cultural Resources Investigation of the Orange Reservoir and Dam, West Orange, Essex County, New Jersey for the Rahway River Flood Risk Management and Ecosystem Restoration Project. Carissa Scarpa, NY District USACE, 2016.

As the study progressed a cultural resources survey was carried out for the Orange Reservoir and Dam, an element of Alternatives 3, 4, 4a, 8, and 9. The survey focused on the dam and reservoir and their eligibility for the NRHP but also involved investigating the surrounding area for additional structures or features that could be impacted by the project. In addition, the survey evaluated the study area for archaeological sensitivity (Figure 3). The investigation included a site visit to the reservoir and research at the New Jersey State Museum (NJSM), the New Jersey Historic Preservation Office (NJHPO), the West Orange Public Library, and Essex County's Department of Parks, Recreation, and Cultural Affairs.

The Orange Reservoir and Dam is potentially eligible for listing on the NRHP. Further research is required to complete a determination of eligibility on this property. An intensive-level architectural survey was recommended. A review of local histories, historic maps, survey data, and records held at the NJSHPO and the New Jersey State Museum (NJSM) indicated that the potential for prehistoric and historic archaeological resources at the Orange Reservoir is high, however, the ground within the study area has been disturbed by construction of the

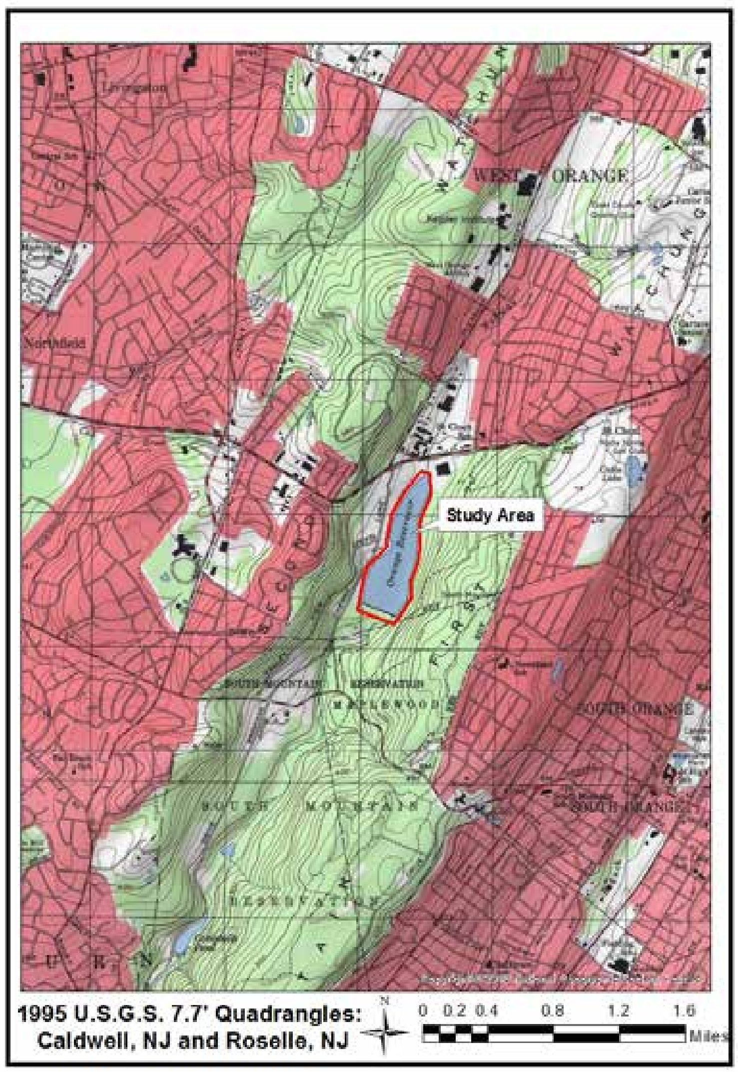


Figure 3: Orange Reservoir and Dam Study Area

reservoir itself as well as later modifications to the dam, and recent construction of the walking path surrounding the reservoir. Archaeological testing was recommended should the project plans include ground disturbance to determine the presence or absence of significant archaeological deposits. Development of a testing plan was recommended to address the potential for deeply buried prehistoric deposits beneath fill and also archaeological deposits relating to the construction of the dam and reservoir and other post construction activities centered on the reservoir.

Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restorations Project, Robinsons Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey. Panamerican Consultants, Inc. 2013.

In 2013 a reconnaissance-level investigation was carried out for the Robinson's Branch Section. The survey was carried out early in the development of alternatives for Robinsons Branch, therefore the study area was simply defined at that time as a 500-foot perimeter surrounding the Rahway River and the Robinson's Branch of the Rahway River. The survey involved a review of the historical and cultural contexts for the project area; the enumeration of all previously-identified cultural resources within it; an assessment of its archaeological sensitivity; and a general discussion / overview of above-ground cultural resources in the APE (Figure 4). The map analysis, prehistoric and historic contexts of Union County, the review of known nearby archaeological sites, and the results the archaeological surface reconnaissance indicate that, in general, the Rahway River Flood Risk Management and Ecosystem Restoration Project area is archaeologically sensitive.

In addition to a large number of individual historic properties, six historic districts are located within the APE: Rahway River Parkway Historic District (ID #4079), Union County Park System Historic District (ID #4424), Upper Rahway Historic District (ID #4948), Lower Rahway Historic District/Main Street (ID #2711), Regina Historic District (ID #4048), and the Pennsylvania Railroad Historic District (ID #4568). At the nexus of the Upper Rahway Historic District, the Lower Rahway Historic District, and the Regina Historic District at Irving Street, along Central Avenue, Hamilton Street and Coach Street, lies the municipally-designated "Arts District," at the heart of which lies the Rahway Theater (NR #860001509; ID #2714). Many of these historic districts overlap each other.

Six Union County parks are located within the APE: Rahway River Parkway (ID #4079); Rahway River Park (ID #2713); Milton Lake Park; Wheatena Park; Bezega Park/Allen Conservation Area; and the Clark Wildlife Preserve and Habitat. In addition, the Rahway River Scenic Tail, also a part of the Union County Park System, is located within the APE. There are also three City of Rahway municipal parks: Veterans Memorial Field complex, Berzinec Park, and Rahway Kiwanis Park. All the above mentioned parks with the exception of Clark Wildlife Preserve and Habitat are contributing elements to the National Register eligible Rahway River Parkway Historic District (ID #4079). Additional research was recommended once the alternative was selected, assessment of the individual structures within the APE as well as a review and possible updating of the historic district boundaries was suggested.

An archaeological sensitivity assessment was carried out for the study area consisting of historic map analysis, review of archaeological contexts for Union County, review of known archaeological sites in the area and surface reconnaissance in the study area. Nearly all of the study area was considered sensitive for historical and prehistoric archaeological resources.

Pending selection of a design alternative, shovel testing was recommended for all areas where the project will have below-ground impacts. Deep testing strategies were recommended for areas where the ground surface has been artificially elevated with the understanding that some fill, having been added for construction of historic homes along the River, may also contain historic materials. In addition to this, an intensive-level architectural assessment was recommended for the areas impacted by the project.

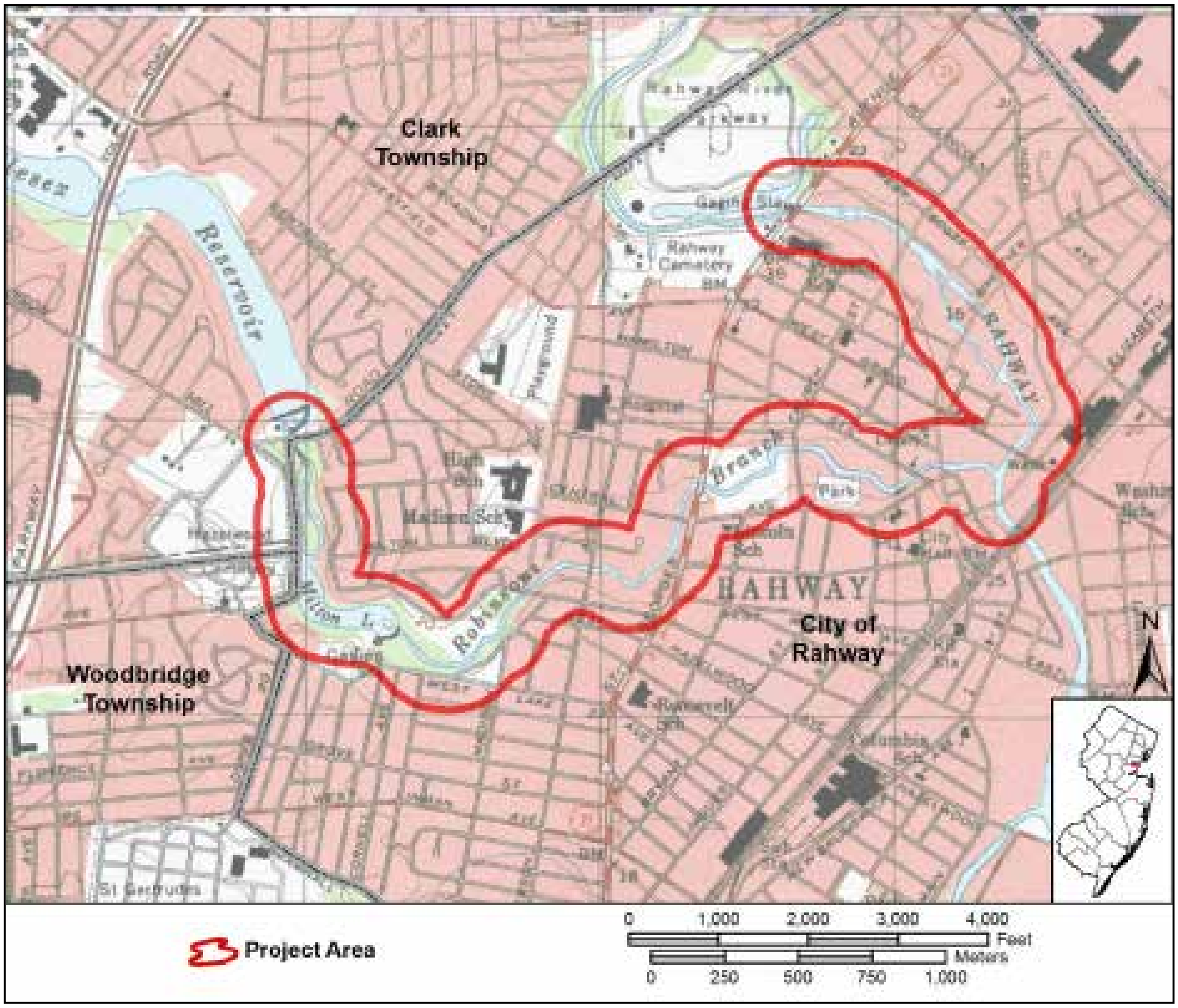


Figure 4: Robinson's Branch Cultural Resources Reconnaissance-Level Investigation Study Area

III. TSP (Tentatively Selected Plan)

Evaluation and comparison of alternatives has been carried out for the Cranford and Robinsons Branch portions of the project. Through economic analysis the alternative that maximized net benefits for each section was selected as the Tentatively Selected Plan (TSP).

Cranford TSP

Figures 5 & 6: Cranford TSP Alternative 4a

The alternative selected for the Cranford section of the TSP is Alternative 4a (Figures 5 and 6). The plan consists of modification to the Orange Reservoir and Dam and channel modification along the Rahway River in Cranford. During the Preconstruction and Engineering Design Phase investigations will be carried out to determine what modifications will be necessary to bring the Orange Reservoir Dam into compliance with U.S. Army Corps of Engineers Dam Safety standards. The scope of the modifications will therefore range from installation of two additional 36 in. diameter outlet pipes to replacement in-kind. The plan requires operation of the dam for a 10ft. to 15ft drawdown of the reservoir two days prior to a storm event.

The channel modification consists of creation of a trapezoidal channel with a natural bed along a 1.7 mile stretch of the Rahway River in Cranford Township. The segment of the River receiving channel modification begins at the footbridge crossing the Rahway River just south of Nomahegan Park and ends at the Lincoln Avenue Bridge further downstream. The new channel would have a natural bed with a 35-45 ft. bottom width. Side slopes would be one vertical on two and a half horizontal (1:2.5). The Hansel Dam and Droescher's Dam would likely be removed as well.

Robinsons Branch TSP

Table I presents the two non-structural alternatives that were analyzed for the Robinson's Branch section of the project. Non-structural flood-proofing measures were evaluated for structures located within the 10-year and the 100-year flood plains. The TSP for the Robinsons Branch Section is Alternative 2a, the 10-year (10% Annual Exceedance) non-structural plan. Approximately 21 structures would receive nonstructural flood damage reduction measures under this plan. The majority of the structures would be elevated and a small number would receive wet flood-proofing or ringwalls.

Table 1: Robinson's Branch Nonstructural Plan for the 10% and 1% annual exceedance events

Nonstructural Flood-Proofing Measures	10% (10-yr) Annual Exceedance			1% (100-yr) Annual Exceedance		
	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total
Dry Flood proofing	0	0	0	11	7	18
Wet Flood proofing	1	1	2	2	3	5
Barriers	2	4	6	3	10	13
Raise	13	0	13	188	0	188
Buyout	0	0	0	0	0	0
Total of Structures	16	5	21	204	20	224

Following selection of the TSP and prior to release of the Final EIS, the District will carrying out optimization of the selected plan to reduce risk and uncertainty with cost data, engineering effectiveness, environmental and cultural resources impacts, and economic benefits. For the Cranford Section the District is in the process of gathering additional data and carrying out further analysis to improve the accuracy of the plan and as a result some elements of the plan are subject to change. For the Robinsons Branch section the number of structures may change based on more detailed analysis and data gathered for the specific properties. Property owner participation will also be a factor in determining which structures will ultimately receive non-structural flood-proofing measures.

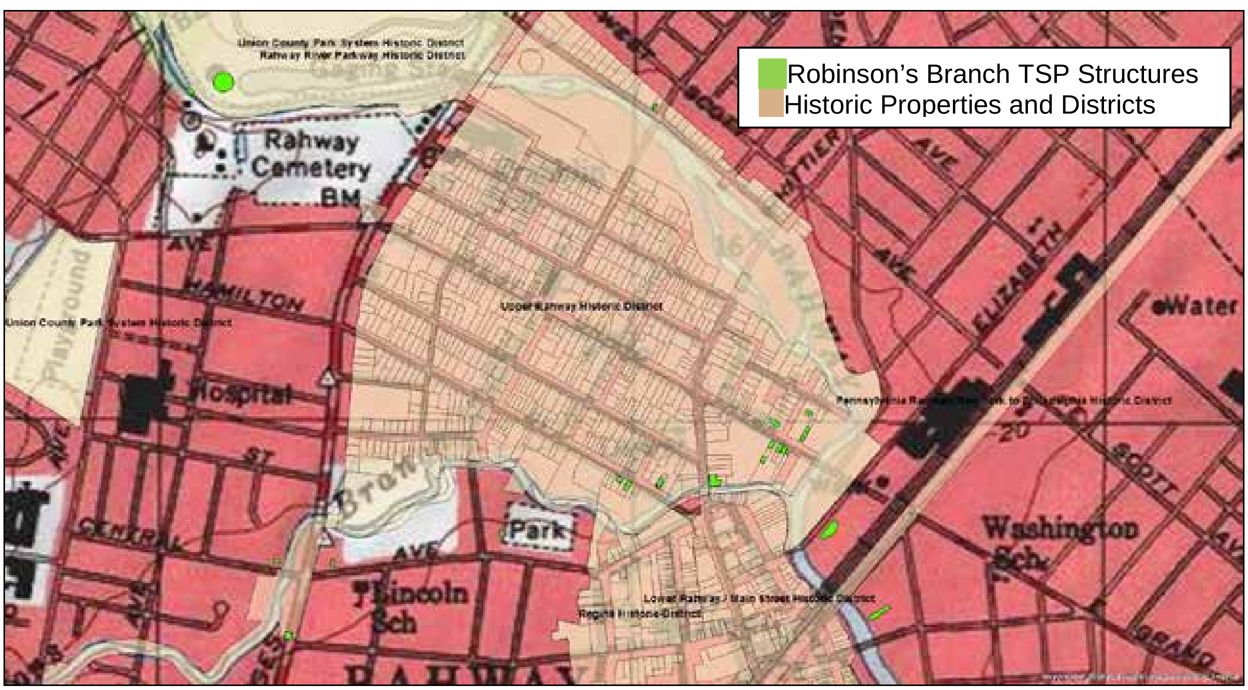


Figure 7: Robinson's Branch TSP

IV. The Area of Potential Effect and Potential Adverse Effects

The Area of Potential Effect (APE) for the Cranford section of the TSP includes areas of channel modification within the Rahway River, the Orange Reservoir and Dam, permanent and temporary construction easements along the banks of the channel and around the reservoir and any staging or mitigation areas. The study areas for the Phase IA Cultural Resources Investigation and the Phase I Cultural Resources Investigation of the Orange Reservoir and Dam addressed the APE for Alternative 4A.

The Cranford section of the APE overlaps with four NRHP-eligible historic districts. These are the North Cranford Historic District, the Rahway River Parkway Historic District, the Union County Park System Historic District, and the Central New Jersey Main Line Corridor Historic District. In addition to these, a number of historic resources are located within the APE in Cranford. Table 2 below lists the historic resources that have been identified within the APE as well as the NRHP status of the resource. Most of the resources within the APE are eligible for the NRHP as contributing elements to a historic district.

Table 2: Historic Properties within the Cranford Section TSP

Resource	NRHP Status	Approximate Date of Construction
Girl Scout Park	Eligible as a contributing element to the North Cranford Historic District (NCHD)	Unknown
Hanson Park/Hanson House	Eligible as contributing element to the NCHD	1990
McConnell Park	Eligible as contributing element to the NCHD	1919
Hampton Park	Eligible as contributing element to the NCHD and the RRPHD	1969
Memorial Park	Eligible as a contributing element to the NCHD and the RRPHD	Unknown
Sperry Park	Eligible as contributing element to the NCHD, Rahway River Parkway Historic District (RRPHD), and Union County Park System HD	1926
Lincoln Park	Eligible as a contributing element to the NCHD and the RRPHD	1917
Cranford Section of Rahway River Parkway HD	Eligible as contributing element to the Rahway River Parkway HD	Unknown
12 Hampton Road (House and Garage)	Eligible as contributing to NCHD	Ca. 1920
20 Hampton Road	Eligible as contributing element to the North Cranford Historic District	Ca. 1920
8 Hampton Street	Eligible as contributing element to NCHD	Ca. 1930
16 Hampton Street	Eligible	Unknown
18 Hampton Street	Eligible as contributing element to NCHD	Ca. 1930
204 Hampton Street (Garage)	Eligible as contributing element to the NCHD and Rahway River Parkway HD	1920

Resource	NRHP Status	Approximate Date of Construction
208 Hampton Street	Eligible as contributing element to NCHD	1914
Culvert crossing Rahway River at Hampton Street	Eligible as contributing element to the NCHD and the RRPHD	1980
Eastman Street Bridge at Hampton Street	Eligible as contributing element to the NCHD, RRPHD, and Union county Park System HD	2004
2 Central Ave and Garage	Eligible as contributing elements to the NCHD	1925
5 Central Ave	Eligible as contributing to the NCHD	1930
7 Central Ave	Eligible as contributing to the NCHD	Unknown
22 Central Ave	Eligible as contributing to the NCHD	Unknown
10 Central Ave and Garage	Eligible as contributing elements to the NCHD	1926
8 Central Ave and Garage	Eligible as contributing elements to the NCHD	1920
6 Central Ave and Garage	Eligible as contributing element to the NCHD	Unknown
126 Eastman Ave	Eligible as contributing elements to the NCHD	1925
122 Eastman Ave	Eligible as contributing elements to the NCHD	1923
Bridge on Eastman Avenue at Holly Street (NJDOT #2003025)	Eligible as a contributing element to the RRPHD, NCHD, and Union County Park System HD	1970
9 Holly Street and Garage	Eligible as contributing element to the NCHD	1920
11 Holly Street and Shed	Eligible as a contributing element to the NCHD but the shed is not	Unknown
102 Orchard Street	Eligible as contributing element to the NCHD	1914
104 Orchard Street and Garage	Eligible as contributing element to the NCHD	1900
106 Orchard Street and Garage	Eligible as contributing element to the NCHD	1900
114 Orchard Street and Garage	Eligible as a contributing element to the NCHD, not the garage	1914
Cranford Canoe Club	Eligible as contributing element to the NCHD	Various
Bridge on Springfield Avenue at Orange Street	Eligible as contributing element to the RRPHD and the Union County Park System HD	2010
107 Riverside Drive	Eligible as contributing element to the NCHD	1900
107 Riverside Drive Culvert and Walls	Eligible as contributing element to the NCHD	Unknown

Resource	NRHP Status	Approximate Date of Construction
Bridge on Union Avenue crossing the Rahway River at Sperry Park	Eligible as contributing element to the NCHD, RRPHD, and Union County Park System HD	1916
12 Forest Street	Eligible as contributing element to the NCHD	1915
18 Forest Street and Garage	Eligible as contributing element to the NCHD, garage not eligible	1930
22 Forest Street and Garage	Eligible as contributing element to the NCHD, garage not eligible	1930
26 Forest Street	House is eligible as a contributing element to the NCHD, garage is undetermined	Unknown
Bridge at North Avenue and Centennial Avenue	Eligible as a contributing element to the RRPHD, and the Union County Park System HD	1965
Central Railroad of NJ Bridge at Centennial Avenue and crossing the Rahway River	Eligible as a contributing element to the CNJ Main Line Corridor HD	1929
Central RR Storage building	Eligible as a contributing element to the CNJ Main Line Corridor HD	Unknown
Bridge at South Avenue and Centennial Ave	Eligible as a contributing element to the RRPHD and the Union County Park System HD	1983
Entry gates, walls, urns, seating area in Lincoln Park	Eligible as contributing elements to NRE Lincoln Park which is a contributing element to the RRPHD and the Union County Park System HD	1917

Alterations to the River within historic districts and parks as well as to the grounds or other features associated with NRHP-eligible historic properties has the potential to result in adverse effects, however, the boundaries of the North Cranford Historic District and the contributing structures and elements that were identified in the Phase IA survey have not been formally defined using survey forms. Additionally, the individual parks in the Union County Park System Historic District have not been evaluated for their individual eligibility as historic properties. In order to conclude identification of resources, an architectural survey will be required for the APE, this will inform the determination of adverse effects.

The APE for the replacement of the Orange Reservoir and Dam includes the dam, the reservoir, and any construction or staging areas utilized as part of the undertaking. The Orange Reservoir and Dam have the potential to be determined eligible for the NRHP however a formal architectural survey is required to make that determination. Besides the dam and reservoir, there are no NRHP-eligible or listed properties or archaeological sites within the APE. Some portions of the APE are archaeologically sensitive, and furthermore, it is likely that staging for construction will expand to overlap with the South Mountain Reservation Historic District. The proposed modification or replacement of the Dam and its associated features has the potential to result in adverse effects and additional survey will be necessary as the plan is developed.

The APE for the Robinson's Branch section of the TSP includes the structures receiving flood-proofing measures, the areas surrounding the structures where excavation and staging are planned and areas where ring walls are planned. The Reconnaissance-Level Cultural Resources Investigation of the Robinson's Branch section addressed the APE for the TSP. Six NRHP eligible historic districts exist within the study area. The majority of the study area lies within those historic district boundaries and many of the structures identified for non-structural flood-proofing measures either have been determined eligible or are potentially eligible for the NRHP. Architectural survey will be required once the structures receiving non-structural flood-proofing measures are finalized to determine their NRHP-eligibility. Archaeological survey may also be required for staging and construction areas.

V. Section 106 Coordination

The District coordinated with the New Jersey State Historic Preservation Office (NJSHPO), the Union County Department of Parks and Community Renewal, and the North Cranford Historic Preservation Advisory Board in 2013 upon completion of the Phase IA and Reconnaissance-level cultural resources surveys for the Cranford and Robinsons Branch portions of the project. In 2016 the District coordinated with the NJSHPO upon completion of the Orange Reservoir survey report. A meeting was held with the NJSHPO in May and the Cranford Preservation Advisory Board in June of 2016 when the TSP was first identified to receive the NJSHPO and the Board's input as well as hear any concerns or recommendations relating to the project. As discussed, to simplify coordination moving forward, two Programmatic Agreements have been prepared. The Cranford Section PA addresses the channel modification along the Rahway River and the modifications to the Orange Reservoir and Dam. The Robinsons Branch Section PA addresses the structure elevation and other non-structural flood-proofing measures planned for structures in that area. The PA lays out the steps that will be taken to determine and address adverse impacts to significant historic resources when the project is authorized to move forward. The PA will be entered into by the U.S. Army Corps of Engineers and the NJSHPO. The Delaware Nation, Delaware Tribe of Indians, Shawnee and Eastern Shawnee Tribes of Oklahoma and the Advisory Council on Historic Preservation have been invited to review and participate as signatories in the PA as well. The Cranford Historic Preservation Advisory Board, the Rahway Historical Society (Mrechant and Drovers Tavern Museum Association) and the West Orange Historic Preservation Commission will be invited to comment upon the PAs. Additional public involvement will be conducted as part of the public review of the EIS and the PA under NEPA and will serve as the District's Section 106 public coordination. The final PA will incorporate comments on the draft document, as appropriate.

Appendix A – Bibliography

Nolte, Kelly, Donald A. Smith, Mark A. Steinback, and Michael Cinquino

2013 Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, and Borough of Kenilworth, Union County, New Jersey. Panamerican Consultants, Inc. Buffalo, NY. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Nolte, Kelly, Donald A. Smith, Mark A. Steinback, and Michael Cinquino

2013 Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey. Panamerican Consultants, Inc. Buffalo, NY. Prepared for U.S. Army Corps of Engineers, New York District, New York.

Scarpa, Carissa

2016 Phase I Cultural Resources Investigation of the Orange Reservoir and Dam, West Orange, Essex County, New Jersey for the Rahway River Flood Risk Management and Ecosystem Restoration Project. New York District, U.S. Army Corps of Engineers.

Appendix B – Coordination

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK, N.Y. 10278-0090

Reply to
Environmental Analysis Branch

October 2, 2012

Mr. Daniel Saunders
Deputy State Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, NJ 08625-0404

Dear Mr. Saunders:

The U.S. Army Corps of Engineers, New York District (District), is pleased to furnish you with a copy of the draft reports *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey* (Enclosure 1) and *Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey* (Enclosure 2). Both the Cranford and Robinson's Branch portions of the Rahway River Flood Risk Management Project are in early planning phases. Alternatives are currently being developed for the Cranford segment of the project. Alternative development has not yet begun for Robinson's Branch. The Phase IA and Reconnaissance reports were prepared in anticipation of additional cultural resources survey work when an alternative is selected.

At this time the District is not assessing project effects. The reports have been prepared in order to identify known resources in the study area and to seek input early on in the planning process from consulting parties. The reports have offered recommendations for further work. The District would welcome the HPO's comments and recommendations in accordance with 36 CFR 800.4. Thank you for your assistance in the Section 106 process. If you or your staff require additional information or have any questions, please contact Carissa Scarpa, Project Archaeologist at (917) 790-8612.

Sincerely,

Nancy J Brighton

Leonard Houston
Chief, Environmental Analysis Branch

Enclosures

State of New Jersey
MAIL CODE 501-04B
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
HISTORIC PRESERVATION OFFICE
P.O. Box 420
Trenton, NJ 08625-0420
TEL. (609) 984-0176 FAX (609) 984-0578

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

November 16, 2012

Leonard Houston, Chief
Environmental Analysis Branch
Department of the Army
Corps of Engineers, New York District
Jacob K. Javits Federal Building
New York, NY 10278-0090

Dear Mr. Houston:

As Deputy State Historic Preservation Officer for New Jersey, in accordance with 36 CFR Part 800: Protection of Historic Properties, as published in the *Federal Register* on December 12, 2000 (65 FR 77725-77739) and amended on July 6, 2004 (69 FR 40544-40555), I am providing Consultation Comments for the following proposed undertaking:

Union and Middlesex Counties
Phase IA Cultural Resources Surveys
Rahway River Flood Risk Management and Ecosystem Restoration Project
United States Department of the Army, Corps of Engineers

Thank you for submitting the following cultural resources reports, received at the Historic Preservation Office (HPO) on October 19, 2012 for the above-referenced undertaking:

Nolte, Kelly, Donald Smith, Mark A. Steinback, and Michael A. Cinquino
2012 *Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey.* Prepared for David Miller & Associates, Inc. Vienna Virginia. Prepared by Panamerican Consultants, Inc. Buffalo, New York.

And

Nolte, Kelly, Donald Smith, Mark A. Steinback, and Michael A. Cinquino
2012 *Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey.* Prepared for David Miller & Associates, Inc. Vienna Virginia. Prepared by Panamerican Consultants, Inc. Buffalo, New York.

800.4 Identification of Historic Properties

Phase IA Cultural Resources Investigation
Townships of Cranford, Springfield, Union, and Westfield, and Borough of Kenilworth

According to the above-referenced report, the United States Army Corps of Engineers is considering several alternatives for the Rahway River Flood Risk Management and Ecosystem Restoration Project, in Union County. The alternatives being considered include: 1) No action; 2) Non-structural measures; 3) Modification of channels, bridges, and the Lenape Detention Basin; 4) Modifications an changes to levees and the Lenape Detention Basin; 6) Alterations to bridges, channels, and the Orang Reservoir; 7) Modifications to channels, bridges, and the South Mountain Reservoir. The report states that the current report addresses alternative 3 and 5, as well as the portions of alternatives 2, 4, 6, 7, and 8 that overlap with alternatives 3 and 5. In addition, the report states that Echo Lake Park, the Orange Reservoir, and the South Mountain Reservoir are parts of alternatives 4, 6, 7, and 8 and are outside the current project area. As a result, these areas will be addressed in a forthcoming investigation which will also include the areas in alternatives 3 and 5 not surveyed as part of this report.

<u>Archaeology</u>

According to the above-referenced reconnaissance-level report, background research has indicated that the entire area of potential effects (APE) for the Rahway River Flood Risk Management and Ecosystem Restoration is sensitive for both Native American and Historic archaeological historic properties. In light of this, the report recommends that once a specific design alternative is chosen, the entire project area should be subjected to Phase IB archaeological survey if the design alternative includes ground disturbing activities in the APE outlined in this report. The report states that Phase IB testing should include a program of standard-interval shovel testing where project activities will have below-ground impacts, as well as the development and implementation of a program for deep-testing in portions of the APE where the ground surface has been artificially elevated. *The HPO concurs with these recommendations.*

The HPO looks forward to continued consultation to identify, evaluate, avoid, and/or mitigate any project impacts on archaeological historic properties, pursuant to Section 106 of the National Historic Preservation Act.

Architecture

The consultant should address the boundaries of the North Cranford Historic District using survey forms. The recommendations section of the cultural resources report notes 44 resources are newly identified as contributing to the North Cranford Historic District, however survey forms were not provided. The HPO looks forward to receiving survey forms for the recommended contributing properties to conclude identification efforts.

The Union County Park system is recognized as a large discontinuous historic district, several Union County Parks lack individualized attention to eligibility as they were assessed as a system of Olmstead designed parks. Depending on the parks within the APE the HPO may need further information on the individual parks, their current configuration/condition, historic conditions, and their character defining features.

Reconnaissance-Level Cultural Resources Investigation, Robinson's Branch Section Township of Clark, City of Rahway, and Township of Woodbridge

According to the report, the information detailed in this reconnaissance-level survey report includes additional measures along the Robinson's Branch of the Rahway River being considered for the Rahway River Flood Risk Management and Ecosystem Restoration project.

Archaeology

According to the above-referenced reconnaissance-level report, background research has indicated that the entire area of potential effects (APE) for the Rahway River Flood Risk Management and Ecosystem Restoration is sensitive for both Native American and Historic archaeological historic properties. In light of this, the report recommends that once a specific design alternative is chosen, the entire project area should be subjected to Phase IB archaeological survey if the design alternative includes ground disturbing activities in the APE outlined in this report. The report states that Phase IB testing should include a program of standard-interval shovel testing where project activities will have below-ground impacts, as well as the development and implementation of a program for deep-testing in portions of the APE where the ground surface has been artificially elevated. *The HPO concurs with these recommendations.*

The HPO looks forward to continued consultation to identify, evaluate, avoid, and/or mitigate any project impacts on archaeological historic properties, pursuant to Section 106 of the National Historic Preservation Act.

Architecture

In order to conclude 800.4 Identification of historic properties the HPO looks forward to reviewing survey forms for the following properties within the APE:

Wheatena Company/Corporation properties
Quinn and Boden Inc.

St. Mary's Roman Catholic Church
Rahway Public Cemetery
Industrial District-Elizabeth Avenue
Robinson's Branch Sign (and other NJDOT signage)
Hazel Wood Cemetery
Potential historic district at St. George and Grand Avenues

We also look forward to receiving new survey forms presenting updated information on the Lower Rahway Historic District, as suggested in the report. In addition to that updated information, the SHPO opinion for the Regina Historic District is rather dated and needs current survey forms.

As mentioned above, although the Union County Park system is recognized as a large discontinuous historic district, several Union County Parks lack individualized attention to eligibility as they were assessed as a system of Olmstead designed parks. Depending on the parks within the APE the HPO may need further information on the individual parks, their current configuration/condition, historic conditions, and its character defining features.

Additional Comments

Thank you for providing the opportunity to review and comment on the potential for the above-referenced project to affect historic properties. The HPO looks forward to further consultation with the Army Corps of Engineers regarding the further development and implementation of the proposed project. If additional consultation with the HPO is needed for this undertaking, please reference the HPO project number 13-0094 in any future calls, emails, or written correspondence to help expedite your review and response. Please do not hesitate to contact Jesse West-Rosenthal (609-684-6019) of my staff with any questions regarding archaeology or Michelle Hughes (609-984-6018) of my staff with questions regarding historic architecture.

Sincerely,

Daniel D. Saunders
Deputy State Historic
Preservation Officer

Cc: Carissa Scarpa - USACE

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK, N.Y. 10278-0090

Reply to
Environmental Analysis Branch

August 14, 2013

Mr. Daniel Saunders
Deputy State Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, NJ 08625-0404

Re: HPO-K2012-106
13-0094-1
Rahway River Flood Risk Management and Ecosystem Restoration Project

Dear Mr. Saunders:

Thank you for your letter, dated November 16, 2012 in which you provided Section 106 consultation comments on the draft reports *Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey* and *Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey.* The U.S. Army Corps of Engineers, New York District (District), has reviewed the HPO's comments and has made an effort to address them briefly here and in the final draft of the reports enclosed with this letter (Enclosures).

Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey

The HPO has requested survey forms for all of the properties recommended as eligible for the National Register of Historic Places, specifically those that are considered contributing elements to the North Cranford Historic District (NCHD). Considering the early planning phase of the current project and the Cranford Historic Preservation Board's (CHPB) present work of redefining the boundaries of the NCHD, the revised report has incorporated survey forms for only those NCHD properties that were identified as a result of this survey so that the forms may be added to your records. Section 5.1.4.1 of the report lists all of the resources within the NCHD and their recommended eligibility status as it was determined by either the architectural historian or the CHPB. As the Rahway River Flood Risk Management Project progresses, an alternative will be selected and it will be clear which resources will be impacted by the selected alternative. At that time the Corps shall carry out any additional work in consultation with your staff to determine the specific impacts and to reduce or avoid such impacts.

Reconnaissance-Level Cultural Resources Investigation, Robinson's Branch Section, Township of Clark, City of Rahway, and Township of Woodbridge

The HPO has requested survey forms for a number of resources recommended eligible for National Register of Historic Places. Because the Corps is still in an early planning phase and no specific alternatives have been proposed this reconnaissance-level survey was not designed as a formal architectural survey but instead was intended to identify known historic resources and archaeological sites within the study area. The District shall carry out a formal architectural survey when an alternative is identified to determine the potential impacts that alternative may have on significant resources.

The HPO has also suggested that many of the individual parks within the Rahway River Parkway Historic District and the Union County Parks Historic District have not been evaluated for their eligibility as individual properties. This will also be addressed at a later date when an alternative is selected and the District has identified which parks will be impacted by the selected alternative.

Finally, please note that the archaeological site registration form for PCI-RAHWAY-1 has been filed with the New Jersey State Museum, Bureau of Archaeology and Ethnology.

Thank you for your assistance in the Section 106 process. If you or your staff require additional information or have any questions, please contact Carissa Scarpa, Project Archaeologist at (917) 790-8612.

Sincerely,

Nancy J. Brighton

for Leonard Houston
Chief, Environmental Analysis Branch

Enclosures

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK, N.Y. 10278-0090

Reply to
Environmental Analysis Branch

August 14, 2013

Daniel J. Bernier, Director
Division of Parks Planning & Environmental Services
Union County Department of Parks & Community Renewal
2325 South Avenue
Scotch Plains, NJ 07076

Dear Mr. Bernier:

The U.S. Army Corps of Engineers, New York District (Corps)) is please to furnish you with digital copies of the reports *Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey* and *Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey (Enclosure).* These surveys were carried out as part of the feasibility phase of the Rahway River Flood Risk Management and Ecosystem Restoration Project.

The Phase IA investigation was partially an update to a cultural resources survey conducted in 1977. The current survey enumerated all previously identified cultural resources, identified areas of archaeological sensitivity, and identified above-ground cultural resources within the areas of potential effect (APE). The survey identified 124 architectural resources and four National Register-eligible (NRE) historic districts as well as one archaeological site and made recommendations for archaeological testing. The Robinson's Branch Reconnaissance survey was also an update to a survey conducted in 1983. It consisted of enumerating all previously-identified cultural resources within the study area, assessment of archaeological sensitivity, and a reconnaissance-level assessment of above-ground cultural resources. The survey identified six National Register-eligible historic districts and a number of individual resources and made recommendations for archaeological testing.

The Corps is considering a number of alternatives for flood risk management along the Rahway River and Robinson's Branch, some which may impact the historic resources identified in these studies. The Corps is looking forward to the opportunity to consult with the Union County Department of Parks as the project moves forward. Please retain these reports for your records and if you wish to share information or have questions or suggestions pertaining to our proposed work and the resources of concern please contact Ms. Carissa Scarpa, Project Archaeologist, at (917)790-8612.

Sincerely,

Nancy J. Brighton
for Leonard Houston,
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK, N.Y. 10278-0090

Reply to
Environmental Analysis Branch

August 16, 2013

Maureen Strazdon, Chair
Cranford Historic Preservation Advisory Board
208 Holly St.
Cranford, NJ 07016

Dear Ms. Strazdon:

The U.S. Army Corps of Engineers, New York District (Corps) is please to furnish you with a copy of the report *Phase IA Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey (Enclosure).* This survey was carried out as part of the feasibility phase of the Rahway River Flood Risk Management and Ecosystem Restoration Project.

The Phase IA investigation was partially an update to a cultural resources survey conducted in 1977. The current survey enumerated all previously identified cultural resources, identified areas of archaeological sensitivity, and identified above-ground cultural resources within the areas of potential effect (APE). The survey identified 124 architectural resources and four National Register-eligible (NRE) historic districts as well as one archaeological site and made recommendations for archaeological testing.

The Corps is considering a number of alternatives for flood risk management along the Rahway River and Robinson's Branch, some which may impact the historic resources identified in these studies. The Corps is looking forward to the opportunity to consult with the Cranford Historic Preservation Advisory Board as the project moves forward. Please retain this report for your records and if you wish to share information or have questions or suggestions pertaining to our proposed work and the resources of concern please contact Ms. Carissa Scarpa, Project Archaeologist, at (917)790-8612.

Sincerely,

L. Houston

Leonard Houston,
Chief, Environmental Analysis Branch

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

REPLY TO
ATTENTION OF

May 17, 2016

Environmental Analysis Branch

Mr. Daniel Saunders
Deputy State Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, NJ 08625-0404

RE: HPO K-2012-106
13-0094-1
Rahway River Flood Risk Management and Ecosystem Restoration Project

Dear Mr. Saunders,

The U.S. Army Corps of Engineers, New York District (District) is continuing to evaluate alternatives for the Rahway River Flood Risk Management and Ecosystem Restoration Project. Recently, the District carried out two reconnaissance level cultural resources investigations to determine the presence of potentially significant cultural resources within the Area of Potential Effect (APE) for a number of alternatives being considered at the time. The resulting reports, entitled *Phase IA Cultural Resources Investigation of the Rahway River Flood Risk Management and Ecosystem Restoration Project, Townships of Cranford, Springfield, Union and Westfield, and Borough of Kenilworth, Union County, New Jersey* and *Reconnaissance-Level Cultural Resources Investigation for the Rahway River Flood Risk Management and Ecosystem Restoration Project, Robinson's Branch Section, Township of Clark and City of Rahway, Union County, and Township of Woodbridge, Middlesex County, New Jersey,* were submitted to your office for review in October of 2012. The surveys identified resources within the study areas that are either listed or are eligible for listing on the National Register of Historic Places (NRHP). In addition, many previously unidentified cultural resources were identified as potentially eligible for listing on the NRHP as a result of these investigations.

At this time a number of the alternatives under consideration include modifications to the Orange Reservoir and Dam, located in West Orange, New Jersey, for flood water storage. The District has carried out a survey of the Orange Reservoir in order to assess the reservoir's significance and eligibility for listing on the NRHP and a brief report has been prepared which summarizes the results of that survey (Enclosed).

Research was conducted at the New Jersey State Museum (NJSM), the New Jersey Historic Preservation Office (NJHPO), the West Orange Public Library, and Essex County's Department of Parks, Recreation, and Cultural Affairs.

The District would welcome the NJHPO's comments and recommendations in accordance with 36 CFR 800.4. Should the selected project alternative include modifications to the Orange Reservoir, the District will carry out additional work, in consultation with your office, in order to determine the potential impacts of the project and to avoid impacts to this resource. Thank you for your assistance in the Section 106 process. If you or your staff require additional information or have any questions, please contact Carissa Scarpa, Project Archaeologist at (917) 790-8612.

Sincerely,

Peter Weppler
Chief, Environmental Analysis Branch

Enclosures

State of New Jersey
MAIL CODE 501-04B
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
HISTORIC PRESERVATION OFFICE
P.O. Box 420
Trenton, NJ 08625-0420
TEL. (609) 984-0176 FAX (609) 984-0578

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

June 23, 2016

Peter M. Weppler
Chief, Environmental Analysis Branch
U.S. Army Corps of Engineers
New York District
Jacob K. Javits Federal Building
New York, New York 10278-0090

Dear Mr. Weppler:

As Deputy State Historic Preservation Officer for New Jersey, in accordance with 36 CFR Part 800: Protection of Historic Properties, as published in the *Federal Register* on December 12, 2000 (65 FR 77725-77739) and amended on July 6, 2004 (69 FR 40544-40555), I am providing continuing Consultation Comments for the following proposed undertaking:

Essex County, West Orange Township
Orange Reservoir and Dam
Rahway River Flood Risk Management and Ecosystem Restoration Project
United States Department of the Army, Corps of Engineers

800.4 Identification of Historic Properties

Thank you for providing the Historic Preservation Office (HPO) with the opportunity to review and comment on the potential for the above-referenced project to affect historic properties. These comments are in response the following Phase I cultural resources survey report, received at this office on May 24, 2016, for the above-referenced undertaking:

Scarpa, Carissa
2016 *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam, West Orange, Essex County, New Jersey for the Rahway River Flood Risk Management and Ecosystem Restoration Project.* Prepared by the United States Department of the Army, Corps of Engineers, New York District.

According to the above-referenced report, the Orange Reservoir and Dam are located along the Rahway River in West Orange Township, Essex County. The reservoir is surrounded to the east, south and west by the South Mountain Reservation Historic District, which was determined eligible for listing on the New Jersey and National Registers of Historic Places on November 18, 2008. The report states that the

Orange Reservoir Dam was built in 1883 during a period of intense urbanization in northeastern New Jersey in the late 19th century. The reservoir supplied 1.7 million gallons of gravity-fed water to the City of Orange along a 16-inch pipeline over a distance of 170,811 feet. This source of water supplied 183 street hydrants for fire protection and later drinking water. Use of the reservoir for water supply was discontinued in 1999.

According to the report, improvements were made to the reservoir and dam in 1958 and again in 1995. Improvements made in 1958 included raising the spillway one foot, placement of a four inch reinforced concrete slab on the downstream spillway apron and placement and grouting of riprap on the upper portion of the upstream face of the dam. Other modifications that predated 1958 but which do not appear on the 1958 plans included placing fill on the eastern side of the dam adjacent to the spillway, construction of a dike along the spillway channel, addition of a by-pass valve, stilling chamber and screens for the water supply outlet, and introduction of an aerator. The 1958 plans also indicate that the reservoir was also lined with a masonry wall. In 1995, improvements included repairing the existing concrete spillway and retaining wall and armoring of the downstream face of the dam with gabion lining. Additional work was carried out on the crest of the dam including clearing trees and vegetation and repaving the surface of the dam crest. During this work, the gatehouse was demolished and the brick masonry pipe gallery under the dam was filled with pea gravel.

Based on background research regarding the Orange Reservoir and Dam, as well as site inspection, the report concludes that although the reservoir and dam have been subject to recent modifications, including repair and reshaping of the embankments and the spillway as well as the demolition of the gate house, the core of the dam and most of the original embankment remain in the same configuration. Additionally, the intake structure, pipes and pipe gallery remain in situ and the stone masonry retaining wall along the banks of the reservoir is found to be in good condition. The report recommends that the Orange Reservoir and Dam is eligible for listing on the New Jersey and National Registers of Historic Places under Criterion A for its connection to the rapid development of suburbs in New Jersey and the transition of the area from rural to suburban. The report also states that the Orange Reservoir and dam are significant under Criterion D for its potential to yield valuable information pertaining to the construction and operation of the dam. *The HPO does not have enough information to concur with assessment at this time.*

Based on the information presented, the HPO finds that additional information and clarifications are needed before the HPO can reach a conclusion regarding the eligibility of the property for listing on the New Jersey and National Registers of Historic Places. Specific questions the HPO has include:

- How does the Orange Reservoir and Dam compare to other reservoirs and dams in New Jersey of this period? New Jersey has at least 4 other reservoirs/dams that have been determined eligible for or are listed on the New Jersey and National Registers of Historic Places that may be used for comparative purposes.
- Why are the Orange Reservoir and Dam significant? What role this the Orange Reservoir and Dam play during its construction and use? Is there anything technologically distinct about the reservoir/dam? Is this the best example of a particular type of engineering and/or construction? Are there any notable people associated with the development of the Orange Reservoir and Dam?
- What was the City of Orange's water supply, prior to the construction of the Orange Reservoir and Dam?
- How does the Orange Reservoir and Dam relate to the South Mountain Reservoir Historic District?

In addition to the questions above, the HPO also recommends contacting the Olmsted Center for Landscape Preservation. The report references that while the Orange Reservoir and Dam were constructed prior to the development of the South Mountain Reservation, it was included in the original plans for the park. While the original documentation for the Orange Reservoir and Dam could not be located as part of this review, the Olmsted Center may have more information on the Orange Reservoir and Dam and its original development.

Additional Comments

Report Comments

The following issues were noted with the submitted survey report:

1. The report submitted does not include the qualifications of the authors who prepared the report. At this point in time, it is unclear whether the Principal Investigator sufficiently meets the Secretary of the Interior's Professional Qualifications Standards for archaeology (48 FR 44738-9). The report should include the qualifications of the Principal Investigator, in the form of a resume or curriculum vitae should be included as an appendix. Inclusion of this document will assist the HPO in properly evaluating whether the Principal Investigator sufficiently meets the National Park Service's Professional Qualifications Standards for archaeology. Please submit a copy of the author's resume or curriculum vitae so that is can be appended to the report.

2. The report submitted did not include a digital copy of the report. The HPO requests that a copy of the final report on the data recovery be submitted in PDF format and be included on a CD.

Thank you for providing the opportunity to review and comment on the potential for the above-referenced project to affect historic properties. Please do not hesitate to contact Jesse West-Rosenthal of my staff at (609) 984-6019 with any questions regarding archaeology or Michelle Craren (609) 292-0032 with questions regarding historic architecture. Please reference the HPO project number 13-0094, in any future calls, emails, or written correspondence to help expedite your review and response.

Sincerely,

Katherine J. Marcopul

Katherine J. Marcopul
Deputy State Historic
Preservation Officer

Cc: Carissa Scarpa, USACE

KJM/MMB/JWR

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
JACOB K. JAVITS FEDERAL BUILDING
26 FEDERAL PLAZA
NEW YORK NY 10278-0090

REPLY TO
ATTENTION OF

August 12, 2016

Environmental Analysis Branch

Ms. Katherine Marcopul
Deputy State Historic Preservation Officer
Historic Preservation Office
New Jersey Department of Environmental Protection
CN 404
Trenton, NJ 08625-0404

RE: HPO K-2012-106
13-0094-1
Rahway River Flood Risk Management and Ecosystem Restoration Project

Dear Ms. Marcopul,

Thank you for providing Section 106 consultation comments regarding the report, titled *Phase I Cultural Resources Investigation of the Orange Reservoir and Dam, West Orange, Essex County, New Jersey for the Rahway River Flood Risk Management and Ecosystem Restoration Project.* As you known, the U.S. Army Corps of Engineers, New York District (District) has been evaluating a number of alternatives for flood risk management including modifications to the Orange Reservoir and Dam. The survey evaluated the Orange Reservoir and Dam for archaeological sensitivity and National Register of Historic Places (NRHP) eligibility. The report concluded that the Orange Reservoir and Dam was eligible for the National Register of Historic Places (NRHP) under Criterion A for its connection to the rapid development of suburbs in New Jersey and the transition of the area from rural to suburban and Criterion D for its potential to yield valuable information pertaining to the construction and operation of the dam. The New Jersey State Historic Preservation Office (HPO) has indicated that in order to concur with this assessment additional information is required. The District concurs with the HPO's recommendation that additional information and clarifications are needed to reach a determination of eligibility.

Modification to the Orange Reservoir and Dam along with channel modification along the Rahway River in Cranford, NJ has recently been identified by the District as the Tentatively Selected Plan (TSP) and the District is proceeding with preparation of an Environmental Impact Statement (EIS) in accordance with the National Environmental

Policy Act (NEPA) to address environmental impacts. Due to funding and scheduling constraints, additional research on the Orange Reservoir and Dam will not be carried out at this time, therefore, the District has revised its recommendations regarding the property to potentially eligible for the NRHP.

In accordance with the Section 106 of the National Historic Preservation Act of 1966, as amended, the District is in the process of preparing a Programmatic Agreement (PA) for the Rahway River Fluvial Flood Risk Management Project that will be coordinated with the HPO, Federally Recognized Tribes, and local interested parties. The PA will outline in detail the activities and tasks that must be carried out to conclude identification of significant resources, determine adverse effects and mitigate for those adverse effects. These activities include carrying out additional archaeological and architectural investigations based on the locations of project elements in coordination and consultation with the HPO, interested parties and Federally Recognized Tribes. The District shall include stipulations in the PA for carrying out an intensive-level architectural survey of the Orange Reservoir and Dam.

Enclosed is a revised copy of the draft report. As requested, the report includes a copy of the author's resume and a digital copy of the report. Thank you for your assistance in the Section 106 process. If you or your staff require additional information or have any questions, please contact Carissa Scarpa, Project Archaeologist at (917) 790-8612.

Sincerely,

Peter Weppler
Chief, Environmental Analysis Branch

Enclosures

Appendix C – Draft Programmatic Agreements

DRAFT
PROGRAMMATIC AGREEMENT
AMONG
THE U. S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
AND
THE NEW JERSEY STATE HISTORIC PRESERVATION OFFICE
REGARDING
THE RAHWAY RIVER FLUVIAL FLOOD RISK MANAGEMENT PROJECT
CRANFORD SECTION
UNION COUNTY, NEW JERSEY

WHEREAS, the U.S. Army Corps of Engineers, New York District, (New York District) plans to carry out the Rahway River Fluvial Flood Risk Management Project (Undertaking) pursuant to the U.S. House of Representatives Resolution Docket 2548, adopted 24 March 1998; and

WHEREAS, the Undertaking consists of two sections, the Cranford section that is the subject of this PA and the Robinson's Branch section that is addressed in another Programmatic Agreement; and

WHEREAS, the Undertaking for the Cranford section, the details of which have not been finalized at this time, consists of channel modification along the Rahway River in Cranford and modification to the Orange Reservoir and Dam in West Orange, NJ (Appendix A); and

WHEREAS, the New York District has defined the "Area of Potential Effect" (APE) for this Undertaking to consist of the areas of channel modification within the Rahway River, the Orange Reservoir and Dam, permanent easements along the banks of the channel and near the Orange Reservoir and Dam and any construction staging and mitigation areas associated with the Undertaking; and

WHEREAS, the New York District is applying the National Register of Historic Places (NRHP) Criteria to properties identified within the APE on a phased basis, and to date has completed a Phase IA cultural resources survey within the APE with the recognition that additional identifications and evaluations are required for project actions which have not yet been finalized (Appendix B); and

WHEREAS, the New York District has conducted a survey of the Orange Reservoir and Dam and has determined that it is potentially eligible for the National Register of Historic Places (NRHP); and

WHEREAS, the APE overlaps with portions of the North Cranford Historic District, the Rahway River Parkway Historic District, the Union County Park System Historic District, and the Central New Jersey Main Line Corridor Historic District as well as many other NRHP-eligible and potentially eligible historic resources; and

WHEREAS, the New York District has determined that the Undertaking has the potential to have an adverse effect on the identified historic properties and districts within the APE; and

WHEREAS, the New York District has not carried out the surveys necessary to conclude identification of historic properties for the selected alternative; and

WHEREAS, the New York District has invited the Advisory Council on Historic Preservation (ACHP), the Delaware Nation, The Delaware Tribe of Indians, the Shawnee Tribe of Oklahoma, the North Cranford Historic Preservation Advisory Board, the Union County Department of Parks, Planning and Community Renewal, the West Orange Historic Preservation Commission, and the Essex County Department of Parks, Recreation, and Cultural Affairs to participate in the Section 106 process; and

WHEREAS the New York District plans to make this Draft PA available for public review in the Draft Environmental Impact Statement prepared under the National Environmental Policy Act which will serve as the District's Section 106 public coordination for this undertaking; and

WHEREAS, the New York District shall implement the provisions of this PA as funding for the Undertaking is appropriated in future years; and

WHEREAS, in accordance with 36 CFR Part 800.14, the New York District and the NJSHPO have determined that execution of this PA will establish alternative procedures to streamline the coordination of the Project as plans are developed and the project moves forward; and

NOW, THEREFORE, the New York District and the signatories agree that the Undertaking shall be administered in accordance with the following stipulations to satisfy the New York District's Section 106 responsibilities for all individual actions of the Undertaking.

Stipulations

The New York District shall ensure that the following measures are carried out:

I. IDENTIFICATION AND EVALUATION

A. Prior to initiation of construction-related activities the New York District, in consultation with the NJSHPO, and the historical societies and the Tribes who have expressed an interest in participating in consultation either as signatories or as concurring parties will design and carry out surveys to complete the identification of historic properties and archaeological sites within the APE.

1. Archaeological Sites

a. The New York District shall ensure that archaeological surveys within the uninvestigated portions of the APE are conducted in a manner consistent with the Secretary of the Interior's Standards and Guidelines for Identification (48 FR 44720-23) and the NJSHPOs Guidelines for Phase I Archaeological Investigations.

b. The survey report will be submitted to the NJSHPO and other consulting parties for review and consultation.

2. Traditional Cultural Properties

a. The New York District will ensure that future surveys within the APE include procedures to identify Traditional Cultural Properties and to consult with Federally Recognized Tribes and other affected parties in accordance with the guidelines provided by National Park Service Bulletin 38, Guidelines for Evaluating and Documenting Traditional Cultural Properties.

b. In the event that a Federally Recognized Tribe or affected group contacts the New York District regarding its recognition of a Traditional Cultural Property located within the APE, the New York District will notify the NJSHPO to initiate discussions to evaluate whether the property is a Traditional Cultural Property that meets the Criteria.

3. Buildings and Structures

a. The New York District will ensure that surveys are conducted for buildings and structures in the APE in a manner consistent with the Secretary of the Interior's Standards and Guidelines for Identification (48 FR 44720-23) and which takes into account the statewide historic contexts developed by the NJSHPO. The survey will be conducted following consultation with the NJSHPO and other signatories, and a report of the survey, consistent with the NJSHPO's Guidelines for Architectural Survey, will be submitted to the NJSHPO and all other consulting parties for review and consultation.

b. The New York District, in consultation with the NJSHPO and the participating historical societies, will identify and evaluate buildings and structures that are located adjacent to listed or eligible NRHP Historic Districts to determine whether such properties should be considered as part of the Historic District or an expanded District.

4. Historic Landscapes and Viewsheds

a. The New York District will consult with the NJSHPO and participating historical societies to identify and evaluate historic landscapes and viewsheds located within the APE. The New York District will consult National Park Service Bulletins 18, How to Evaluate and Nominate Designed Historic Landscapes, and 30 Guidelines for Evaluating and Documenting Rural Historic Landscapes, National Park Service Preservation Brief 36, Protecting Cultural Landscapes, and other publications and materials made available by the NJSHPO to assist in defining the criteria that should be applied to such properties.

b. The objective in conducting the surveys is to identity NRHP listed or potentially eligible historic landscapes and affected viewsheds within the project area that may be adversely affected by the Undertaking, and to determine whether they meet the NRHP criteria set forth in 36 CFR Part 60.4.

B. The New York District will ensure that qualified professionals meeting the National Park Service professional qualifications for the appropriate discipline [National Park Service Professional Qualification Standards, Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44738-39)] are used to complete all identification and evaluation efforts related to this undertaking, to include geomorphological, palynological, and archaeological surveys and testing, and architectural survey.

C. The New York District and the NJSHPO shall consider the views of the public and consulting parties in completing its identification and evaluation responsibilities. See Stipulation VI.A., below, for review periods.

D. Application of Criteria: The New York District, in consultation with the NJSHPO, and participating historical societies will evaluate historic properties using the Criteria established for the NRHP [36 CFR 800.4(c)(1)]:

1. If the New York District and the NJSHPO agree that the Criteria apply or do not apply, in evaluating the NRHP eligibility of a property, the property shall be treated accordingly for purposes of this PA.

2. If the New York District and the NJSHPO disagree regarding NRHP eligibility, or if the ACHP so requests, prior to the start of any project-related work at the site or in the vicinity of the property, the New York District will obtain a formal Determination of Eligibility (DOE) from the Keeper of the National Register (Keeper), National Park Service, whose determination shall be final.

E. The New York District will maintain records of all decisions it makes related to the NRHP eligibility and determination of effects on properties.

II. TREATMENT OF HISTORIC PROPERTIES

A. The New York District will adhere to the following treatment strategies in order to avoid adverse effect to historic properties that have been determined eligible for the NRHP.

   1. Avoidance.   The preferred treatment is avoidance of effects to historic properties. The New York District will, to the extent feasible, avoid historic properties that have been determine eligible for the NRHP either through project design changes, use of temporary fencing or barricades, realignments, landscaping, or other measures that will protect historic properties. The New York District, the NJSHPO, and participating historical societies shall consult to develop plans for avoiding effects to historic properties. The New York District shall incorporate feasible avoidance measures into project activities as part of the implementation of the Undertaking.   If avoidance is determined to be infeasible, the New York District will develop and implement treatment/mitigation plans. Unless the NJSHPO and other consulting parties object within 30 days of receipt of any plan, the New York District will ensure that treatment plans are implemented by the New York District or its representative(s). The New York District will revise plans to address comments and recommendations provided by the NJSHPO and other consulting parties.

   2. Preservation In Place. When the New York District, the NJSHPO, and participating historical societies agree that complete avoidance of historic properties is infeasible, the New York District will explore preservation in place, if appropriate. Preservation in place may entail partial avoidance or protection of historic properties against project-related activities in proximity to the property. The New York District will preserve properties in place through project design, i.e incorporating color, texture, scale, and/or materials which are compatible with the architectural or historic character of the historic property; use of fencing, berms or barricades; and/or preservation of vegetation including mature trees, landscaping and planting which screen the property. If the New York District, in consultation with the NJSHPO and other consulting parties, determines that preservation in place is infeasible, the New York District shall develop and implement mitigation plans consistent with Stipulation III of this PA.

B. The New York District will ensure that qualified professionals meeting the NPS' professional qualifications for the appropriate discipline [National Park Service Professional Qualification Standards, Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44738-39)] are used to develop and implement all treatment plans.

C. Buildings and Structures and Districts

The New York District, in consultation with the NJSHPO and participating historical societies, will determine the effect the undertaking will have on NRHP-listed or eligible historic buildings, districts, and structures and ensure that a treatment plan is developed for these properties.

D. Archaeological Sites

1. Archaeological Data Recovery: The District will develop a data recovery plan for archaeological sites eligible solely under NRHP Criterion D which the New York District and the NJSHPO agree cannot be avoided or appropriately preserved in place. The data recovery plan to retrieve significant archaeological information will be developed and implemented by the New York District or its representative(s), following approval from the NJSHPO and prior to the implementation of project-related activities within or in the vicinity of the archaeological sites.

2. The New York District will ensure that the data recovery plan for each eligible site addresses substantive research questions developed in consultation with the NJSHPO, historical societies, and Federally Recognized Tribes, as appropriate. The plan will be consistent with the <u>Secretary of the Interior's Standards and Guidelines for Archaeological Documentation</u> (48 FR 44734-37) and take into account the ACHP's publication, <u>Treatment of Archaeological Properties.</u>

3. The New York District will submit data recovery plans to the NJSHPO and relevant consulting parties for review and approval. The New York District, the NJSHPO and consulting parties shall consult to resolve any objections to the data recovery plan as proposed. The data recovery plan shall then be implemented by the New York District once approved by the NJSHPO. If no response is received from the NJSHPO or any other consulting party after 30 days of receipt of adequate documentation, the New York District may assume concurrence and proceed with implementation of the plan submitted.

E. Historic Landscapes

1. The New York District, in consultation with the NJSHPO and participating historical societies, shall develop a plan to identify and evaluate design alternatives which will avoid, minimize, or compensate for impacts when it is determined that an NRHP-eligible historic landscape will be affected by undertaking activities.

2. Treatment measures for historic landscapes shall consider, in order of priority, preservation, rehabilitation, restoration, reconstruction, and additions in accordance with <u>The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural</u>

Landscapes (1996) and Protecting Cultural Landscapes, National Park Service Preservation Brief Number 36.

III. RESOLUTION OF ADVERSE EFFECTS

A. When the New York District, in consultation with the NJSHPO and other consulting parties, determines that the Undertaking-related activities cannot adhere to treatment plans developed in accordance with Stipulation II or would otherwise have an adverse effect, the New York District shall:

1. Develop a Standard Mitigation Agreement (SMA) with the NJSHPO and the participating Tribes and historical societies as appropriate; or

2. Consult with the ACHP to develop a Memorandum of Agreement (MOA) in accordance with 36 CFR Part 800.6 (c).

B. The New York District will invite the ACHP to participate in consultation when:

1. The New York District, other consulting parties, and NJSHPO determine that an agreement or a SMA cannot be reached;

2. a National Historic Landmark is involved;

3. human remains have been identified; or

4. there is widespread public interest in a historic property or properties.

C. Development of Standard Mitigation Agreements (SMA).

1. The New York District, in consultation with the NJSHPO and other consulting parties, as appropriate, will develop SMAs for NRHP-eligible or listed historic properties that will be adversely affected by the Undertaking. The New York District will submit the SMA to the NJSHPO and consulting parties for review and approval by certified mail. The NJSHPO shall have 30 days from receipt of adequate information in which to review and comment on the SMA(s). If the NJHPO fails to respond within 30 days, or if there is disagreement, the New York District shall notify the ACHP and consult to develop the proposed SMA into an MOA and submit copies of background information and the proposed SMA to facilitate consultation to develop an MOA in accordance with 36 CFR Part 800. After signing by the New York District, the NJSHPO, and other PA signatories as appropriate, the New York District shall file all SMAs with the ACHP.

2. SMAs developed between the New York District, the NJSHPO, and other consulting parties, may include one or more of the following stipulations which

address routine adverse effects that may occur to historic properties as a result of project implementation.

a. Recordation. The New York District will consult with the NJSHPO or Historic American Building Survey/Historic American Engineering Record (HABS/HAER) to determine the appropriate level and type of recordation for affected resources. For historic properties with state and/or local significance, recordation will be consistent with the requirements and standards of the Department of the Interior (April 2003). All documentation must be submitted to NJHPO and HABS/HAER for acceptance, prior to the initiation of project activities, unless otherwise agreed to by the NJHPO.

b. Salvage and Donation of Significant Architectural Elements. Prior to demolition, partial demolition, or substantial alteration of historic properties, the New York District, in consultation with the NJSHPO and participating historical societies, will develop a salvage and donation plan to identify appropriate parties willing and capable of receiving and preserving the salvaged significant architectural elements. The New York District shall submit the plans to the NJSHPO and the historical societies for review and approval.

c. Alternative Treatments or Design Plan which meet the Standards. Prior to demolition, partial demolition, or substantial alteration of historic properties, the New York District, in consultation with the NJSHPO and participating historical societies, will develop a plan identifying protocols for developing treatment guidelines and evaluating design standards for new construction within historic districts in keeping with the Secretary's Standards. The New York District will submit the plans to the NJSHPO and the historical societies for review and approval.

d. Data recovery for archaeological sites eligible under Criterion D and others and data recovery and treatment of archaeological sites where data recovery will not result in a finding of no adverse effect. The New York District will conduct data recovery on archaeological sites following agreement on the prospective data recovery and treatment plans between the New York District, the NJSHPO, and other consulting parties as appropriate, when the archaeological sites are eligible for National Register inclusion under additional Criteria than Criterion D (for the information which they contain) or when the full informational value of the site cannot be substantially preserved through the conduct of appropriate research to professional standards and guidelines. To the maximum extent feasible, data recovery and treatment plans will be developed prior to construction to take into account and mitigate for the fullest range of archaeological site values and significance. The New York District will submit the plans to the NJSHPO and other consulting parties for review and approval.

D. The New York District, in consultation with the NJSHPO and other consulting parties, will ensure that all materials and records resulting from the survey, evaluation, and data recovery conducted for the Undertaking will be curated in accordance with 36 CFR Part 79 "Curation of Federally-Owned and Administered Archaeological Collections" and ER 1130-2- 433 "Project Operations: Collections Management and Curation of Archaeological and Historical Data." All material and records recovered from non-Federally owned land will be maintained in accordance with 36 CFR Part 79 until their analysis is complete and, if necessary, are returned to their owner(s).

IV. DISCOVERY

A. If previously unidentified properties are discovered during Undertaking implementation, the New York District shall cease all work in the vicinity of the discovered property until it can be evaluated pursuant to the guidelines in Stipulation I of this PA. If the property is determined to be eligible, the New York District will consult with the NJSHPO, and other consulting parties to develop a treatment plan or SMA in accordance with Stipulation III of this PA.

B. The New York District shall implement the treatment plan or SMA once approved by the NJSHPO and consulting parties.

V. TREATMENT OF HUMAN REMAINS:

A. If any human remains and/or grave-associated artifacts are encountered, the New York District, the NJSHPO, other consulting parties, and Tribes as appropriate shall consult to develop a treatment plan that is responsive to the ACHP's "Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects" (February 23, 2007), the Native American Grave Protection and Repatriation Act, As Amended (PL 101-601, 25 U.S.C. 3001 et seq.) and the U.S. Army Corps of Engineers, Tribal Consultation Policy (October 2013).

B. Human remains must be treated with the utmost respect and dignity. All work must stop in the vicinity of the find and the site will be secured.

C. The medical examiner/coroner, local law enforcement, the NJHPO, and Tribes will be notified. The coroner and local law enforcement will determine if the remains are forensic or archaeological in nature.

D. If the remains are determined to be archaeological in nature a physical anthropologist will be employed to investigate the site to determine whether the remains are Native American or of some other origin.

E. If the human remains are determined to be Native American they shall be left in place and protected from further disturbance until a treatment plan has been developed and approved by the New York District, NJHPO and Tribes.

F. If human remains are determined to be non-Native American, the remains will be left in place and protected from further disturbance until a plan for avoidance or removal is developed and approved by the New York District, NJHPO, Federally Recognized Tribes and other parties, as appropriate.

G. Avoidance of human remains is the preferred treatment.

VI. COORDINATION OF REVIEWS FOR STUDY ACTIVITIES

A. All plans, documents, reports, and materials shall be submitted by the New York District to the SHPO and other consulting parties as appropriate by certified mail, for a 30 day review period unless otherwise stipulated in this PA. If the NJSHPO and other consulting parties fail to comment within the specified time the New York District shall assume the agencies' concurrence.

B. When consulting parties are participating in the review of activities or actions outlined in this PA the New York District shall ensure that all consulting parties are provided documentation at the time it is forwarded to the NJSHPO and afforded a 30 day review period. As appropriate, the New York District shall submit the comments of consulting parties to the NJSHPO to facilitate further consultation.

C. If after consulting with the NJSHPO and consulting parties for a period of 90 days on any action or activity provided for in this PA, the New York District or NJSHPO concludes there is no progress in developing treatment/mitigation plans or other documents required by this PA, the New York District or NJSHPO may notify the ACHP and request the its involvement to expedite completion of the consultation process.

D. The New York District shall ensure that all submissions to the NJSHPO, consulting parties, and the ACHP include all relevant information to facilitate their review. The New York District shall provide all additional information requested by NJSHPO, consulting parties, or ACHP within a timely manner unless the signatories to this PA agree otherwise.

E. The New York District shall ensure that all draft and final reports resulting from actions pursuant to the Stipulations of this PA will be provided to the NJSHPO, all other consulting parties to this PA, and will identify the Principal Investigator responsible for the report. All reports will be responsive to contemporary standards, and as appropriate to the <u>Department of the Interior's Format Standards for Final Reports of Data Recovery Programs</u> (42 FR 5377-79) and HPO report standards. Precise locational data may be provided only in a separate appendix if it appears that its release could jeopardize archaeological sites consistent with National Register Bulletin Number 29, Guidelines for Restricting Information about Historic and Prehistoric Resources.

F. If the District proposes revisions or addenda to approved treatment/ mitigation plans or other documents, the New York District, the NJSHPO, and other participating parties shall consult to determine whether additional conditions or mitigation measures are appropriate.

G. The New York District shall certify in writing that all requirements for identification and evaluation, and the implementation of treatment/mitigation plans have been satisfactorily completed prior to the initiation of construction activities for a specified portion of the navigation improvements recommended in the Study. The New York District shall submit a copy of this certification to the NJSHPO and all other consulting parties by certified mail. The NJSHPO and other consulting parties shall have 30 days to object to the certification based on a finding of incomplete compliance or inadequate compliance with the terms of this PA. If the NJSHPO or consulting parties do not object, the District may proceed with construction for the specified segment of the Study.

VII. ADMINISTRATIVE TERMS

A. DISPUTE RESOLUTION

1. The New York District will attempt to resolve any disagreement arising from implementation of this PA. If there is a determination that the disagreement cannot be resolved, the New York District will request the ACHP`s recommendations or request the comments of the ACHP in accordance with 36 CFR Part 800.6(b).

2. Any ACHP recommendations or comments provided in response will be considered in accordance with 36 CFR Part 800.6(b), with reference only to the subject of the dispute. The New York District will respond to ACHP recommendations or comments indicating how the New York District has taken the ACHP's recommendations or comments into account and complied with same prior to proceeding with undertaking's activities that are subject to dispute. Responsibility to carry out all other actions under this PA that are not the subject of the dispute will remain unchanged.

3. If the ACHP does not provide its advice regarding the dispute within the thirty (30) calendar day time period, the New York District may make a final decision on the dispute and proceed accordingly. Prior to reaching such a final decision, the New York District will prepare a written response that takes into account any timely comments regarding the dispute from the consulting

parties to the MOA, and provide them and the ACHP with a copy of such written response.

B. Public Involvement

1. In consultation with the NJSHPO and other consulting parties, the New York District will develop a plan to inform potential interested parties of the existence of this Agreement, and the New York District's plan for meeting the terms of this PA. Copies of this Agreement and relevant documentation prepared pursuant to the terms of this PA shall be made available for public inspection (information regarding the locations of archaeological sites will be withheld in accordance with the Freedom of Information Act and National Register Bulletin 29, if it appears that this information could jeopardize archaeological sites). Any comments received from the public under this Agreement shall be taken into account by the New York District.

2. Public Objections. The New York District will review and resolve timely substantive public objections. Public objections shall be considered timely when they are provided within the review periods specified in this PA. The New York District shall consult with the NJSHPO and other participating historical societies or Tribes, and as appropriate with the ACHP, to resolve objections. Study actions which are not the subject of the objection may proceed while the consultation is conducted.

C. Monitoring

1. The New York District will prepare annual reports summarizing the status of compliance with the terms of this PA and a summary of the completed activities and the exempt activities for the past year and proposed activities for the next fiscal year. Reports shall be submitted by January 31 of every year. The Annual Reports shall be provided to ACHP, the NJSHPO, and all other consulting parties until the Study-related activities are complete.

2. The ACHP, the NJSHPO, and other consulting parties may request a site visit to follow up on information in the annual report or to monitor activities carried out pursuant to this PA. The ACHP, the NJSHPO, or other consulting party will provide the New York District with 30 days written notice when requesting a site visit unless otherwise agreed. The New York District may also schedule a site visit with the NJSHPO, other consulting parties, and the ACHP at its discretion.

D. Amendments

Any signatory to this PA may request that it be amended, whereupon all the parties will consult in accordance with 36 CFR Part 800.6(b) to consider such amendment.

E. Termination

Any signatory to this PA may terminate it by providing thirty (30) days' notice to the signatories, provided that the signatories will consult during the period prior to termination by certified mail to seek agreement on amendments or other actions that would avoid termination. In the event of termination, the New York District will comply with 36 CFR Parts 800.4 through 800.6 with regard to individual Undertaking actions covered by this Agreement.

F. Sunset Clause

This PA will continue in full force and effect until the construction of the Undertaking is complete and all terms of this PA are met, unless the Project is terminated or authorization is rescinded or a period of seven (7) years from execution of the PA has passed at which time the agreement may be extended as written provided all signatories concur.

G. Anti-Deficiency Act

All requirements set forth in this PA requiring expenditure of funds by the New York District are expressly subject to the availability of appropriations and the requirements of the Anti-Deficiency Act (31 U.S.C. 1341). No obligation undertaken by the New York District under the terms of this PA shall require or be interpreted to require a commitment to extend funds not appropriated for a particular purpose. If the New York District cannot perform any obligation set forth in this PA because of unavailability of funds, that obligation must be renegotiated among the New York District and the consulting parties as necessary.

Execution and implementation of this PA evidences that the New York District has satisfied its Section 106 responsibilities for all individual Undertakings of the Project, and that the New York District has afforded the ACHP an opportunity to comment on the undertaking and its effects on historic properties.

U.S. ARMY CORPS OF ENGINEERS

By: ______________________________ Date: _________________
David A. Caldwell
Colonel, U.S. Army
Commander

NEW JERSEY STATE HISTORIC PRESERVATION OFFICE

By: ______________________________ Date: _________________
Katherine Marcopul, Deputy State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

By: ______________________________ Date: _________________

DELAWARE NATION

By: ______________________________ Date: _________________

DELAWARE TRIBE OF INDIANS

By: ______________________________ Date: _________________

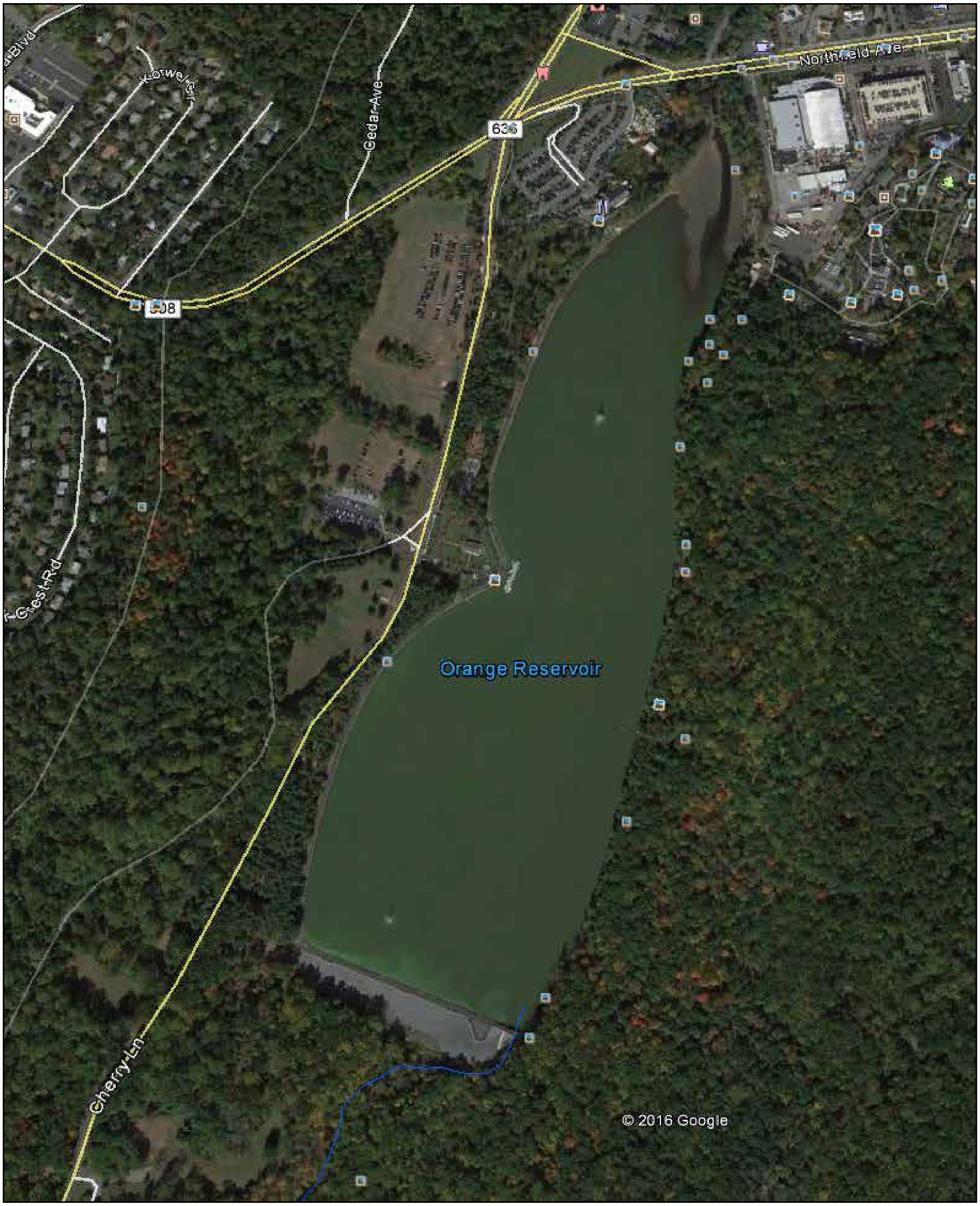
SHAWNEE TRIBE OF OKLAHOMA

By: ______________________________ Date: _________________

Appendix A: Cranford Tentatively Selected Plan
Appendix B: Cultural Resources Survey Areas

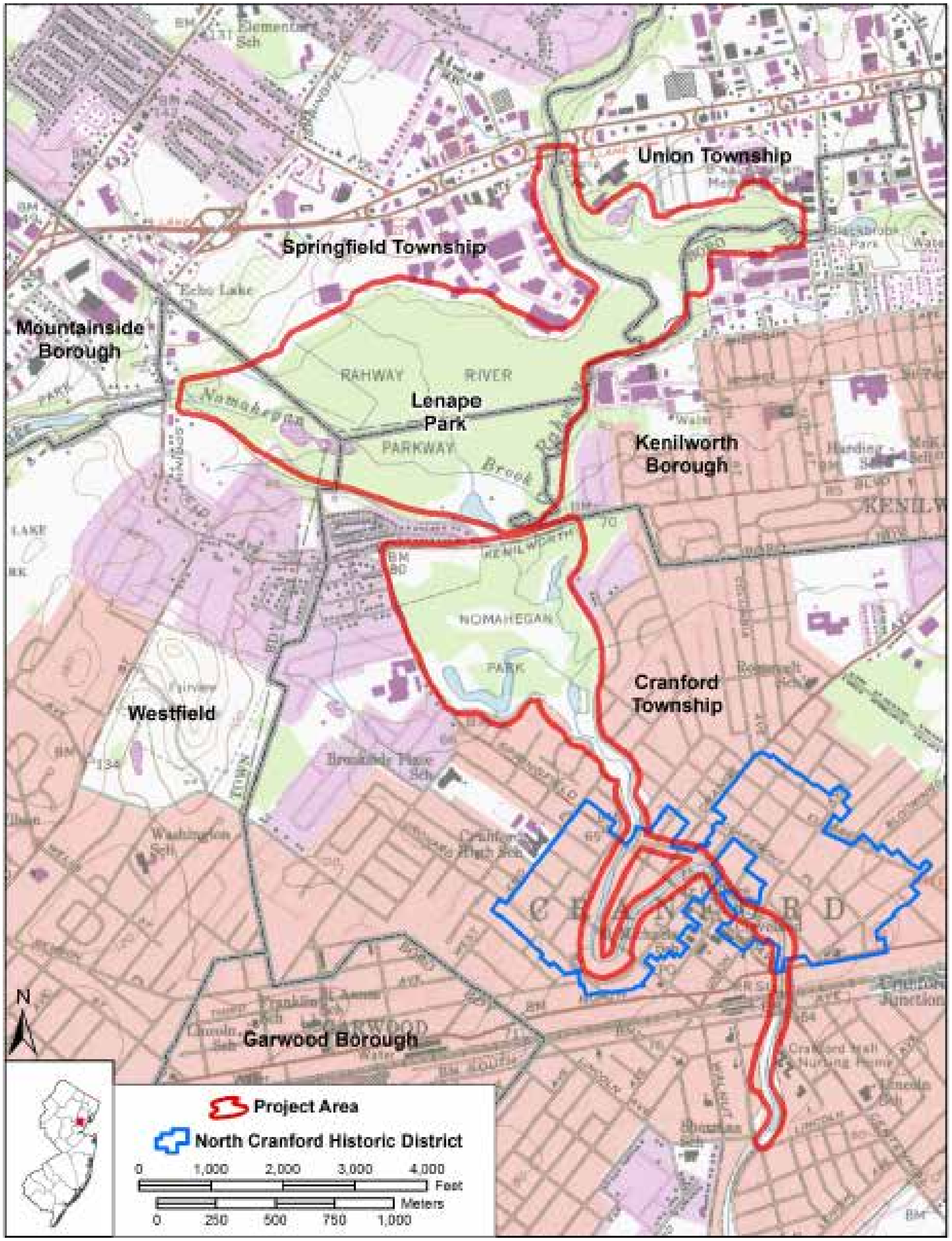
APPENDIX A – Cranford Section Plan

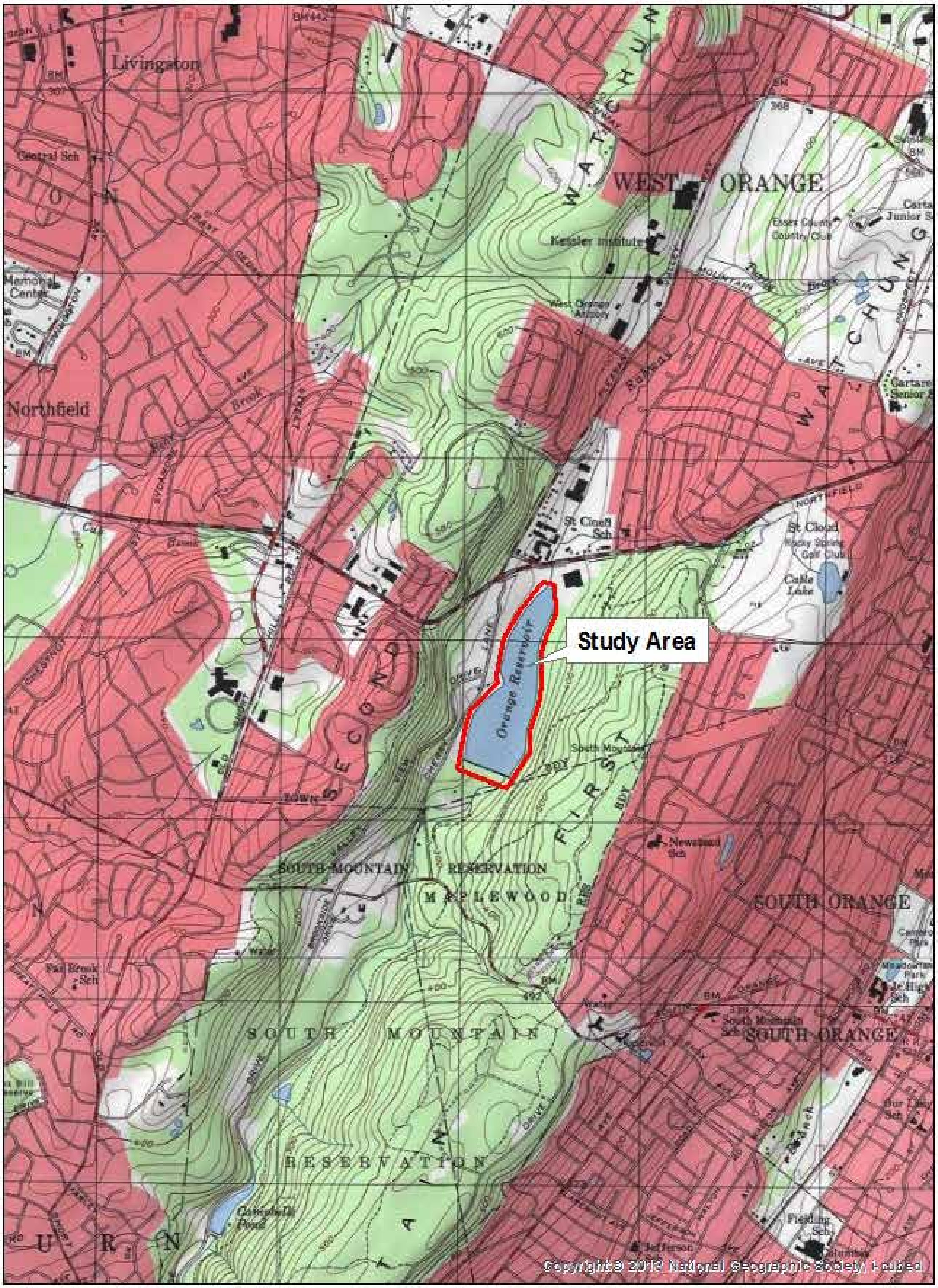
Channel Modification in Cranford, NJ



Modifications to Orange Reservoir and Dam

APPENDIX B – The Phase IA Cultural Resources Survey Study Area for Cranford and Orange Reservoir and Dam





1995 U.S.G.S. 7.7' Quadrangles: Caldwell, NJ and Roselle, NJ

N

0 0.2 0.4 0.8 1.2 1.6 Miles

DRAFT
PROGRAMMATIC AGREEMENT
AMONG
THE U. S. ARMY CORPS OF ENGINEERS, NEW YORK DISTRICT
AND
THE NEW JERSEY STATE HISTORIC PRESERVATION OFFICE
REGARDING
THE RAHWAY RIVER FLUVIAL FLOOD RISK MANAGEMENT PROJECT
ROBINSON'S BRANCH SECTION
UNION COUNTY, NEW JERSEY

WHEREAS, the U.S. Army Corps of Engineers, New York District, (New York District) plans to carry out the Rahway River Fluvial Flood Risk Management Project (Undertaking) pursuant to the U.S. House of Representatives Resolution Docket 2548, adopted 24 March 1998; and

WHEREAS, the Undertaking consists of two sections, the Robinson's Branch section that is the subject of this Programmatic Agreement (PA) and the Cranford section that is addressed in another PA; and

WHEREAS, the Undertaking for the Robinsons' Branch section consists of non-structural flood proofing measures that will be carried out for structures that are located within areas of flooding along the Robinson's Branch of the Rahway River. Non-structural flood-proofing measures are expected to consist of elevating structures, wet-proofing, dry-proofing, and ringwalls, however, may also involve other activities that are undetermined at this time (Appendix A); and

WHEREAS, the New York District has defined the "Area of Potential Effect" (APE) for this Undertaking as consisting of the structures selected for non-structural flood-proofing measures as well as the area surrounding the structures where excavation and staging are planned and areas where ringwalls are planned as well as any additional areas affected by the Undertaking; and

WHEREAS, the New York District is in the process of refining the plan and the exact number and location of the structures that will be receiving treatment is not yet determined; and

WHEREAS, the New York District is applying the National Register of Historic Places (NRHP) Criteria to properties identified within the APE on a phased basis, and to date has completed a Reconnaissance-level cultural resources survey for portions of the APE which will be hereafter referred to as the "Investigated Portion of the APE" with the recognition that when the plan is finalized and individual structures are selected for flood proofing further investigation will be carried out; and

WHEREAS, the New York District has determined that portions of the APE are within historic districts including the Rahway River Parkway Historic District, the Union County Parks System Historic District, the Regina Historic District, the Lower Rahway/Main Street Historic District, and the Pennsylvania RR NY to Philadelphia Historic District; and

WHEREAS, the New York District has determined that many of the structures within the APE are potentially eligible, eligible, or listed on the NRHP either as individual elements or as contributing elements to one or more historic districts; and

WHEREAS, the New York District has determined that the Undertaking has the potential to have an adverse effect on the identified historic properties and districts within the APE; and

WHEREAS, the New York District has not carried out the surveys necessary to conclude identification of historic properties within the APE; and

WHEREAS, the New York District has invited the Advisory Council on Historic Preservation (ACHP), the Delaware Nation, The Delaware Tribe of Indians, the Shawnee Tribe of Oklahoma and the Merchants and Drovers Tavern Museum Association to participate in the Section 106 consultation process; and

WHEREAS the New York District plans to make this Draft PA available for public review in the Draft Environmental Impact Statement prepared under the National Environmental Policy Act which will serve as the District's Section 106 public coordination for this Undertaking; and

WHEREAS, in accordance with 36 CFR Part 800.14, the New York District and the NJSHPO have determined that execution of this PA will establish alternative procedures to streamline the coordination of the Project; and

WHEREAS, the New York District shall implement the provisions of this PA as funding for the Undertaking is appropriated in future years; and

NOW, THEREFORE, the New York District and the NJSHPO agree that the Undertaking will be administered in accordance with the following stipulations to satisfy the New York District's Section 106 responsibility for all individual actions of the Undertaking.

Stipulations

The New York District shall ensure that the following measures are carried out:

I. IDENTIFICATION AND EVALUATION

A. Prior to initiation of construction-related activities the New York District, in consultation with the NJSHPO, the Tribes, historical societies, and other interested parties will design and carry out surveys to complete the identification of historic properties and archaeological sites within the APE.

   1. Archaeological Sites

      a. The New York District shall ensure that archaeological surveys within the APE are conducted in a manner consistent with the Secretary of the Interior's Standards and Guidelines for Identification (48 FR 44720-23) and the NJSHPOs Guidelines for Phase I Archaeological Investigations.

      b. The survey reports will be submitted to the NJSHPO, Tribes, historical societies, and all other consulting parties for review.

   2. Traditional Cultural Properties.

      a. The New York District will ensure that future surveys within the APE include procedures to identify Traditional Cultural Properties and to consult with Federally Recognized Tribes and other affected parties in accordance with the guidelines provided by National Park Service Bulletin 38, <u>Guidelines for Evaluating and Documenting Traditional Cultural Properties</u>.

      b. In the event that a Federally Recognized Tribe or affected group contacts the New York District regarding its recognition of a Traditional Cultural Property, located within the APE, the New York District will notify the NJSHPO and the Tribes to initiate discussions with all parties to evaluate whether the property is a Traditional Cultural Property that meets the Criteria.

   3. Buildings and Structures

      a. The New York District will ensure that surveys are conducted for buildings and structures in the APE in a manner consistent with the <u>Secretary of the Interior's Standards and Guidelines for Identification</u> (48 FR 44720-23) and which takes into account the statewide historic contexts developed by the NJSHPO. The survey will be conducted following consultation with the NJSHPO, historical societies, and other consulting parties, and a report of the survey, consistent with the NJSHPO's <u>Guidelines for Architectural Survey</u>, will be submitted to all consulting parties for review.

b. The New York District, in consultation with the NJSHPO, historical societies, and other consulting parties, will identify and evaluate buildings and structures that are located adjacent to listed or eligible NRHP Historic Districts to determine whether such properties should be considered as part of the Historic District or an expanded District.

4. Historic Landscapes and Viewsheds

   a. The New York District will consult with the NJSHPO, historical societies, and all other consulting parties to identify and evaluate historic landscapes and viewsheds located within the APE. The New York District will consult National Park Service Bulletins 18, How to Evaluate and Nominate Designed Historic Landscapes, and 30 Guidelines for Evaluating and Documenting Rural Historic Landscapes, National Park Service Preservation Brief 36, Protecting Cultural Landscapes, and other publications and materials made available by the NJSHPO to assist in defining the criteria that should be applied to such properties.

   b. The objective in conducting the surveys is to identity NRHP listed or potentially eligible Historic Landscapes and affected View Sheds within the project area that may be adversely affected by the Undertaking, and to determine whether they meet the NRHP criteria set forth in 36 CFR Part 60.4.

B. The New York District will ensure that qualified professionals meeting the National Park Service professional qualifications for the appropriate discipline [National Park Service Professional Qualification Standards, Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44738-39)] are used to complete all identification and evaluation efforts related to this Undertaking, to include geomorphological, palynological, and archaeological surveys and testing, and architectural survey.

C. The New York District shall consider the views of the historical societies, all consulting parties, and the public in completing its identification and evaluation responsibilities. See Stipulation VI.A., below, for review periods.

D. Application of Criteria: The New York District, in consultation with the NJSHPO and historical societies will evaluate historic properties using the Criteria established for the NRHP [36 CFR 800.4(c)(1)]:

   a. If the New York District and the NJSHPO agree that the Criteria apply or do not apply, in evaluating the NRHP eligibility of a property, the property shall be treated accordingly for purposes of this PA.

b. If the New York District and the NJSHPO disagree regarding NRHP eligibility, or if the ACHP so requests, prior to the start of any project-related work at the site or in the vicinity of the property, the New York District will obtain a formal Determination of Eligibility (DOE) from the Keeper of the National Register (Keeper), National Park Service, whose determination shall be final.

E. The New York District will maintain records of all decisions it makes related to the NRHP eligibility and determination of effects on properties.

II. TREATMENT OF HISTORIC PROPERTIES.

A. The New York District will adhere to the following treatment strategies in order to avoid adverse effect to historic properties that have been determined eligible for the NRHP.

1. <u>Avoidance</u>. The preferred treatment is avoidance of effects to historic properties. The New York District will, to the extent feasible, avoid historic properties that have been determined eligible for the NRHP either through project design changes, use of temporary fencing or barricades, realignments, landscaping, or other measures that will protect historic properties. The New York District, in consultation with the NJSHPO, historical societies, and other consulting parties, shall develop plans for avoiding effects to historic properties. The New York District shall incorporate feasible avoidance measures into project activities as part of the implementation of the Undertaking. If avoidance is determined to be infeasible, the New York District will develop and implement treatment/mitigation plans. Unless the NJSHPO, the historical societies, and other consulting parties object within 30 days of receipt of any plan, the New York District will ensure that treatment plans are implemented by the New York District or its representative(s). The New York District will revise plans to address comments and recommendations provided by the NJSHPO and other consulting parties.

2. Preservation In Place. When the New York District and other consulting parties agree that complete avoidance of historic properties is infeasible, the New York District will explore preservation in place, if appropriate. Preservation in place may entail partial avoidance or protection of historic properties against project-related activities in proximity to the property. The New York District will preserve properties in place through project design, i.e incorporating color, texture, scale, and/or materials which are compatible with the architectural or historic character of the historic property; use of fencing, berms or barricades; and/or preservation of vegetation including mature trees, landscaping and planting which screen the property. If the New York District, in consultation with the NJSHPO and other consulting parties, determines that

preservation in place is infeasible, the New York District shall develop and implement mitigation plans consistent with Stipulation III of this PA.

B. The New York District will ensure that qualified professionals meeting the NPS' professional qualifications for the appropriate discipline [National Park Service Professional Qualification Standards, Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44738-39)] are used to develop and implement all treatment plans.

C. Buildings and Structures and Districts

The New York District, in consultation with the NJSHPO, historical societies and other consulting parties, will determine the effect the Undertaking will have on NRHP-listed or eligible historic buildings, districts, and structures and ensure that a treatment plan is developed for these properties.

D. Archaeological Sites

1. Archaeological Data Recovery: The District will develop a data recovery plan for archaeological sites eligible solely under NRHP Criterion D which the New York District and the NJSHPO agree cannot be avoided or appropriately preserved in place. The data recovery plan to retrieve significant archaeological information will be developed and implemented by the New York District or its representative(s), following approval from the NJSHPO and in consultation with other consulting parties prior to the implementation of project-related activities within or in the vicinity of the archaeological sites.

2. The New York District will ensure that the data recovery plan for each eligible site addresses substantive research questions developed in consultation with the NJSHPO and Federally Recognized Tribes, as appropriate. The plan will be consistent with the Secretary of the Interior's Standards and Guidelines for Archaeological Documentation (48 FR 44734-37) and take into account the ACHP's publication, Treatment of Archaeological Properties.

3. The New York District will submit data recovery plans to the NJSHPO, the tribes, historical societies and other consulting parties for review and approval. The New York District shall consult to resolve any objections to the data recovery plan as proposed. The data recovery plan will then be implemented by the New York District once approved by the NJSHPO. If no response is received from the NJSHPO or other consulting parties after 30 days of receipt of adequate documentation, the New York District may assume the NJSHPO's and other consulting parties' concurrence and proceed with implementation of the plan submitted.

E. Historic Landscapes

1. The New York District, in consultation with the NJSHPO, historical societies, and other consulting parties, shall develop a plan to identify and evaluate design alternatives which will avoid, minimize, or compensate for impacts when it is determined that an NRHP-eligible historic landscape will be affected by the Undertaking.

2. Treatment measures for historic landscapes shall consider, in order of priority, preservation, rehabilitation, restoration, reconstruction, and additions in accordance with The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes (1996) and Protecting Cultural Landscapes, National Park Service Preservation Brief Number 36.

III. RESOLUTION OF ADVERSE EFFECTS

A. When the New York District, in consultation with the NJSHPO and other consulting parties, determines that the Undertaking-related activities cannot adhere to treatment plans developed in accordance with Stipulation II or would otherwise have an adverse effect, the New York District shall:

1. Develop a Standard Mitigation Agreement (SMA) with the NJSHPO and the other signatories; or

2. Consult with the ACHP to develop a Memorandum of Agreement (MOA) in accordance with 36 CFR Part 800.6 (c).

B. The New York District will invite the ACHP to participate in consultation when:

1. The New York District, the NJSHPO, and other signatories, determine that an agreement or a SMA cannot be reached;

2. a National Historic Landmark is involved;

3. human remains have been identified; or

4. there is widespread public interest in a historic property or properties.

C. The New York District, the NJSHPO, and other consulting parties as appropriate, will consult to develop alternatives to mitigate or minimize adverse effects. The analysis of alternatives shall consider program needs, cost, public benefit and values, and design feasibility.

D. Development of Standard Mitigation Agreements (SMA).

   1. The New York District, in consultation with the NJSHPO and other signatories, as appropriate, will develop SMAs for NRHP-eligible or listed historic properties that will be adversely affected by the Undertaking. The New York District will submit the SMA to the NJSHPO for review and approval by certified mail. The NJSHPO shall have 30 days from receipt of adequate information in which to review and comment on the SMA(s). If the NJHPO fails to respond within 30 days, or if there is disagreement, the New York District shall notify the ACHP and consult to develop the proposed SMA into an MOA and submit copies of background information and the proposed SMA to facilitate consultation to develop an MOA in accordance with 36 CFR Part 800. After signing by the New York District and NJSHPO, the New York District shall file all SMAs with the ACHP.

   2. SMAs developed between the New York District and the NJSHPO may include one or more of the following stipulations which address routine adverse effects that may occur to historic properties as a result of project implementation.

      a. Recordation. The New York District will consult with the NJSHPO or Historic American Building Survey/Historic American Engineering Record (HABS/HAER) to determine the appropriate level and type of recordation for affected resources. For historic properties with state and/or local significance, recordation will be consistent with the requirements and standards of the Department of the Interior (April 2003). All documentation must be submitted to NJHPO and HABS/HAER for acceptance, prior to the initiation of project activities, unless otherwise agreed to by the NJHPO.

      b. Salvage and Donation of Significant Architectural Elements. Prior to demolition, partial demolition, or substantial alteration of historic properties, the New York District, in consultation with the NJSHPO, will develop a salvage and donation plan to identify appropriate parties willing and capable of receiving and preserving the salvaged significant architectural elements. The New York District shall submit the plans to the NJSHPO for review and approval.

c. Alternative Treatments or Design Plan which meet the Standards. Prior to demolition partial demolition, or substantial alteration of historic properties, the New York District, in consultation with the NJSHPO, will develop a plan identifying protocols for developing treatment guidelines and evaluating design standards for new construction within historic districts in keeping with the Secretary's Standards. The New York District will submit the plans to the NJSHPO for review and approval.

d. Data recovery for archaeological sites eligible under Criterion D and others and data recovery and treatment of archaeological sites where data recovery will not result in a finding of no adverse effect. The New York District will conduct data recovery on archaeological sites following agreement on the prospective data recovery and treatment plans between the New York District and the NJSHPO when the archaeological sites are eligible for National Register inclusion under additional Criteria than Criterion D (for the information which they contain) or when the full informational value of the site cannot be substantially preserved through the conduct of appropriate research to professional standards and guidelines. To the maximum extent feasible, data recovery and treatment plans will be developed prior to construction to take into account and mitigate for the fullest range of archaeological site values and significance. The New York District will submit the plans to the NJSHPO and other signatories for review and approval.

E. The New York District, in consultation with the NJSHPO and other signatories, will ensure that all materials and records resulting from the survey, evaluation, and data recovery conducted for the Undertaking will be curated in accordance with 36 CFR Part 79 "Curation of Federally-Owned and Administered Archaeological Collections" and ER 1130-2- 433 "Project Operations: Collections Management and Curation of Archaeological and Historical Data." All material and records recovered from non-Federally owned land will be maintained in accordance with 36 CFR Part 79 until their analysis is complete and, if necessary, are returned to their owner(s).

IV. DISCOVERY

A. If previously unidentified properties are discovered during Undertaking implementation, the New York District shall cease all work in the vicinity of the discovered property until it can be evaluated pursuant to the guidelines in Stipulation I of this PA. If the property is determined to be eligible, the New York District will consult with the NJSHPO, the Tribes and other consulting parties to develop a treatment plan or SMA in accordance with Stipulation III of this PA.

B. The New York District shall implement the treatment plan or SMA once approved by the NJSHPO.

V. TREATMENT OF HUMAN REMAINS:

A. If any human remains and/or grave-associated artifacts are encountered, the New York District, the NJSHPO, other consulting parties and Tribes shall consult to develop a treatment plan that is responsive to the ACHP's "Policy Statement Regarding Treatment of Burial Sites, Human Remains and Funerary Objects" (February 23, 2007), the Native American Grave Protection and Repatriation Act, As Amended (PL 101-601, 25 U.S.C. 3001 et seq.) and the U.S. Army Corps of Engineers, Tribal Consultation Policy (October 2013).

B. Human remains must be treated with the utmost respect and dignity. All work must stop in the vicinity of the find and the site will be secured.

C. The medical examiner/coroner, local law enforcement, the NJHPO, and tribes will be notified. The coroner and local law enforcement will determine if the remains are forensic or archaeological in nature.

D. If the remains are determined to be archaeological in nature a physical anthropologist will be employed to investigate the site to determine whether the remains are Native American or of some other origin.

E. If the human remains are determined to be Native American they shall be left in place and protected from further disturbance until a treatment plan has been developed and approved by the New York District, NJHPO and the Tribes.

F. If human remains are determined to be non-Native American, the remains will be left in place and protected from further disturbance until a plan for avoidance or removal is developed and approved by the New York District, NJHPO, and other consulting parties, as appropriate.

G. Avoidance of human remains is the preferred treatment.

VI. COORDINATION OF REVIEWS FOR STUDY ACTIVITIES

A. All plans, documents, reports, and materials shall be submitted by the New York District to the SHPO and signatories by certified mail, for a 30 day review period unless otherwise stipulated in this PA. If the NJSHPO and other signatories fail to comment within the specified time the New York District shall assume the agencies concurrence.

B. When interested parties are participating in the review of activities or actions outlined in this PA the New York District shall ensure that all interested parties are provided documentation at the time it is forwarded to the SHPO and afforded a 30 day review period. As appropriate, the New York District shall submit the comments of interested parties to the SHPO to facilitate further consultation.

C. If after consulting with the NJSHPO and consulting parties for a period of 90 days on any action or activity provided for in this PA, the New York District or NJSHPO concludes there is no progress in developing treatment/mitigation plans or other documents required by this PA, the New York District or NJSHPO may notify the Council and request the Council's involvement to expedite completion of the consultation process.

D. The New York District will ensure that all submissions to the NJSHPO, interested parties, and the Council include all relevant information to facilitate their review. The New York District will provide all additional information requested by NJSHPO, interested parties, or Council within a timely manner unless the signatories to this PA agree otherwise.

E. The New York District will ensure that all draft and final reports resulting from actions pursuant to the Stipulations of this PA will be provided to the NJSHPO, and upon request, to interested parties and will identify the Principal Investigator responsible for the report. All reports will be responsive to contemporary standards, and as appropriate to the Department of the Interior's Format Standards for Final Reports of Data Recovery Programs (42 FR 5377-79) and HPO report standards. Precise locational data may be provided only in a separate appendix if it appears that its release could jeopardize archaeological sites consistent with National Register Bulletin Number 29, Guidelines for Restricting Information about Historic and Prehistoric Resources.

F. If the District proposes revisions or addenda to NJSHPO approved treatment/ mitigation plans or other documents, the New York District and NJSHPO will consult to determine whether additional conditions or mitigation measures are appropriate.

G. The New York District will certify in writing that all requirements for identification and evaluation, and the implementation of treatment/mitigation plans have been satisfactorily completed prior to the initiation of construction activities for a specified portion of the navigation improvements recommended in the Study. The New York District shall submit a copy of this certification to the NJSHPO and by certified mail. The SHPO and shall have 30 days to object to the certification based on the NJSHPO's finding of incomplete compliance or inadequate compliance with the terms of this PA. If the NJSHPO does not object, the District may proceed with construction for the specified segment of the Study.

VII. ADMINISTRATIVE TERMS

A. Dispute Resolution

1. The New York District will attempt to resolve any disagreement arising from implementation of this PA. If there is a determination that the disagreement cannot be resolved, the New York District will request the ACHP`s recommendations or request the comments of the ACHP in accordance with 36 CFR Part 800.7.

2. Any ACHP recommendations or comments provided in response will be considered in accordance with 36 CFR Part 800.7, with reference only to the subject of the dispute. The New York District will respond to ACHP recommendations or comments indicating how the New York District has taken the ACHP's recommendations or comments into account and complied with same prior to proceeding with undertaking's activities that are subject to dispute. Responsibility to carry out all other actions under this PA that are not the subject of the dispute will remain unchanged.

3. If the ACHP does not provide its advice regarding the dispute within the thirty (30) calendar day time period, the New York District may make a final decision on the dispute and proceed accordingly. Prior to reaching such a final decision, the New York District will prepare a written response that takes into account any timely comments regarding the dispute from the signatories and concurring parties to the MOA, and provide them and the ACHP with a copy of such written response.

B. Public Involvement

1. In consultation with the NYSHPO, the New York District shall develop a plan to inform the interested parties of the existence of this Agreement, and the New York District's plan for meeting the terms of this PA. Copies of this Agreement and relevant documentation prepared pursuant to the terms of this PA shall be made available for public inspection (information regarding the locations of archaeological sites will be withheld in accordance with the Freedom of Information Act and National Register Bulletin 29, if it appears that this information could jeopardize archaeological sites). Any comments received from the public under this Agreement shall be taken into account by the New York District.

2. Public Objections. The New York District shall review and resolve timely substantive public objections. Public objections shall be considered timely when they are provided within the review periods specified in this PA. The New York District shall consult with the relevant SHPO, and as appropriate

with the Council, to resolve objections. Study actions which are not the subject of the objection may proceed while the consultation is conducted.

C. Monitoring

1. The New York District shall prepare annual reports summarizing the status of compliance with the terms of this PA and a summary of the completed activities for the past year as well as ongoing and proposed activities for the next calendar year. Reports shall be submitted by January 31 of every year. The Annual Reports shall be provided to Council, the NJSHPO, and all other consulting parties until the work identified in this PA is complete.

2. The Council and the NJSHPO may request a site visit to follow up information in the annual report or to monitor activities carried out pursuant to this PA. The Council and the NJSHPO shall provide the New York District with 30 days written notice when requesting a site visit unless otherwise agreed. The New York District may also schedule a site visit with the NJSHPO's and the Council at its discretion.

D. Amendments

Any signatory to this PA may request that it be amended, whereupon all the parties will consult in accordance with 36 CFR Part 800.6(b) to consider such amendment.

E. Termination

Any signatory to this PA may terminate it by providing thirty (30) days' notice to the signatories, provided that the signatories will consult during the period prior to termination by certified mail to seek agreement on amendments or other actions that would avoid termination. In the event of termination, the New York District will comply with 36 CFR Parts 800.4 through 800.6 with regard to individual Undertaking actions covered by this Agreement.

F. Sunset Clause

This PA will continue in full force and effect until the construction of the Undertaking is complete and all terms of this PA are met, unless the Project is terminated or authorization is rescinded or a period of seven (7) years from execution of the PA has passed at which time the agreement may be extended as written provided all signatories concur.

G. Anti-Deficiency Act

All requirements set forth in this PA requiring expenditure of funds by the New York District are expressly subject to the availability of appropriations and the requirements of the Anti-Deficiency Act (31 U.S.C. 1341). No obligation undertaken by the New York District under the terms of this PA shall require or be interpreted to require a commitment to extend funds not appropriated for the Undertaking. If the New York District cannot perform any obligation set forth in this PA because of unavailability of funds, that obligation must be renegotiated among the New York District and the signatories as necessary.

Execution and implementation of this PA evidences that the New York District has satisfied its Section 106 responsibilities for all actions associated with the Undertaking, and that the New York District has afforded the ACHP an opportunity to comment on the Undertaking and its effects on historic properties.

U.S. ARMY CORPS OF ENGINEERS

By: ______________________________ Date: ________________
David A. Caldwell
Colonel, U.S. Army
Commander

NEW JERSEY STATE HISTORIC PRESERVATION OFFICE

By: ______________________________ Date: ________________
Katherine Marcopul, Deputy State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

By: ______________________________ Date: ________________

DELAWARE NATION

By: ______________________________ Date: ________________

DELAWARE TRIBE OF INDIANS

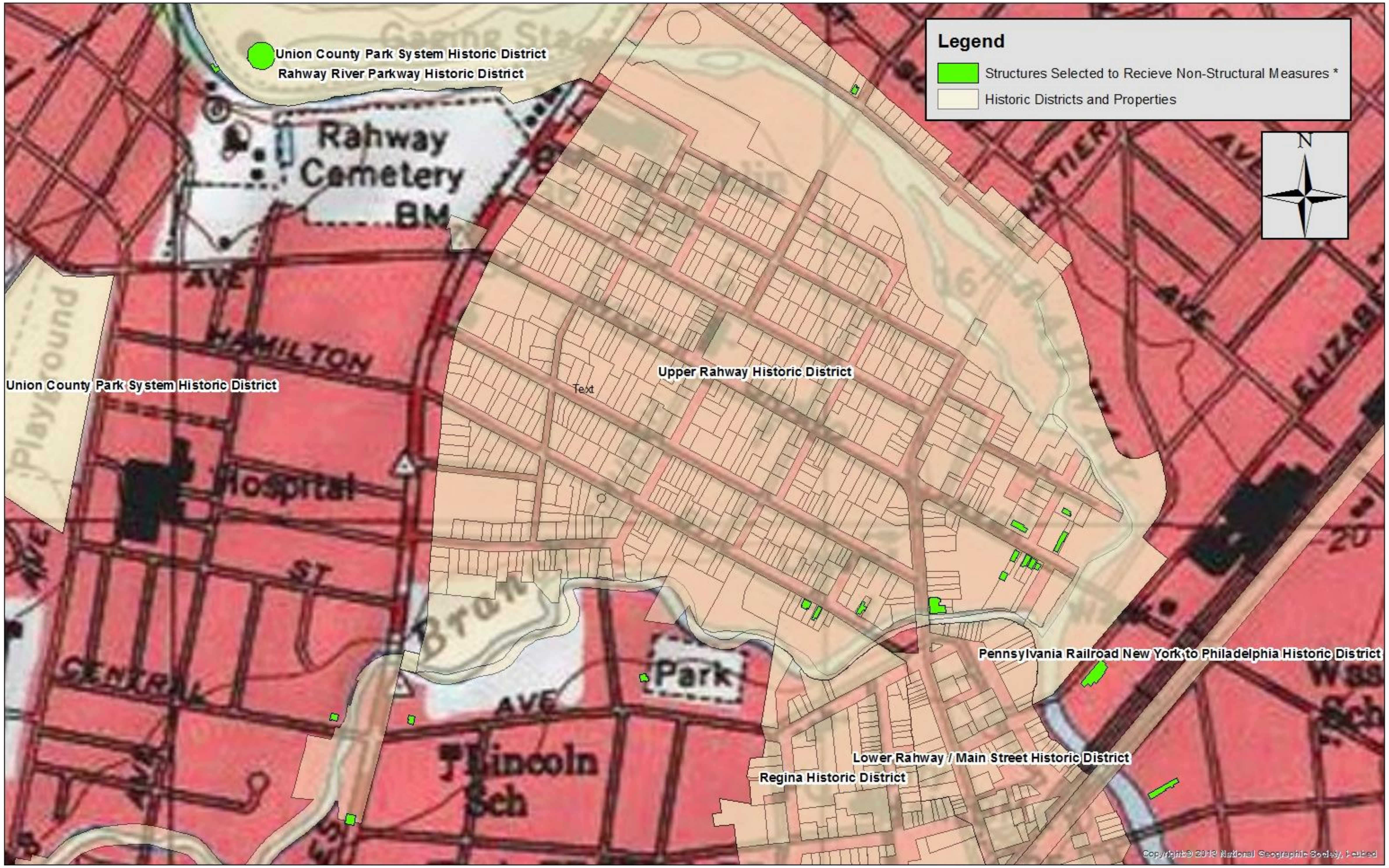
By: ______________________________ Date: ________________

SHAWNEE TRIBE OF OKLAHOMA

By: ______________________________ Date: _________________

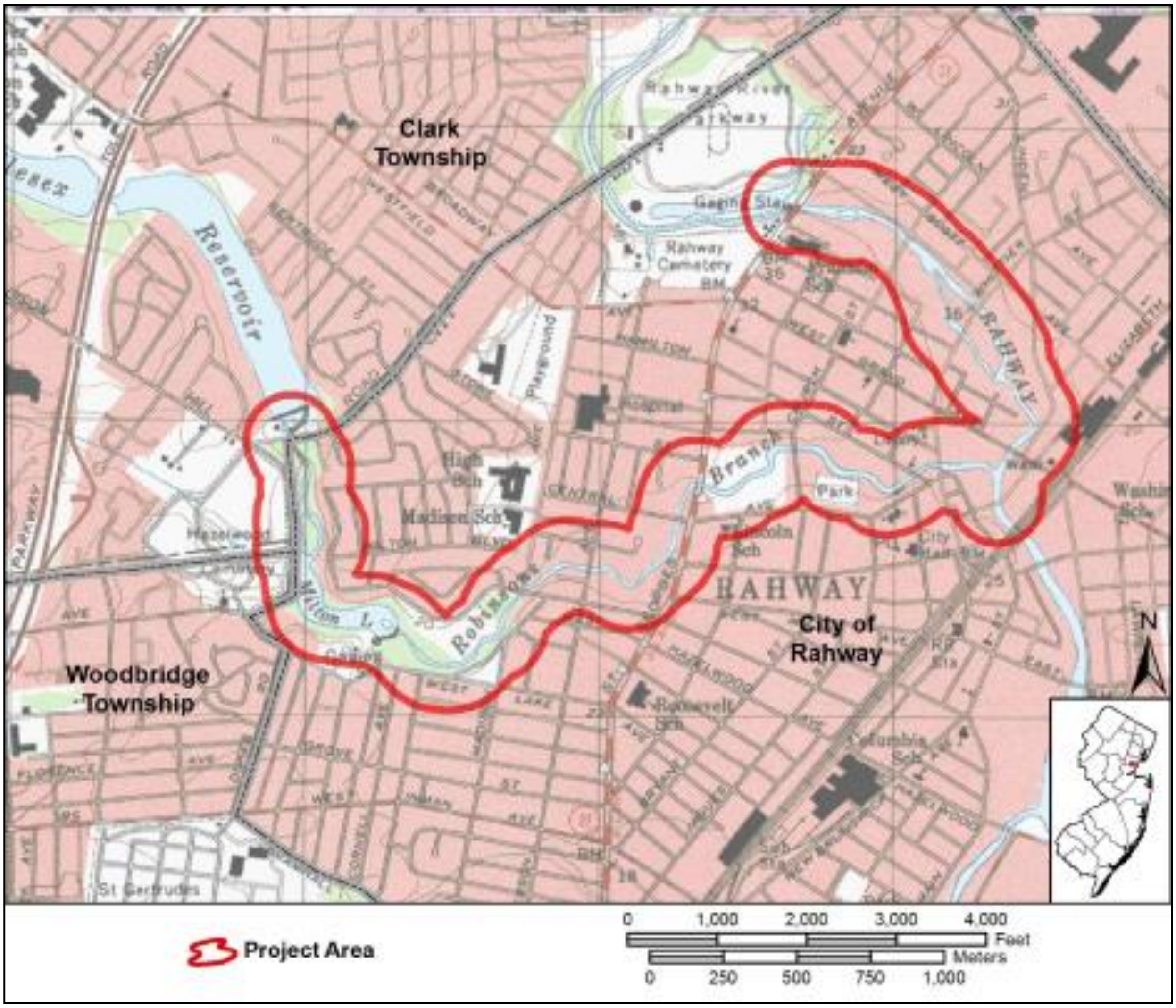
Appendix A: Robinsons Branch Project Area 100-Year Inundation Area and Historic Resources
Appendix B: Cultural Resources Survey Study Area

Appendix A: Robinson's Branch Project Area Showing Non-Structural Alternative and Historic Resources



* The list of structures is subject to change as plans are developed.

APPENDIX B – Cultural Resources Reconnaissance Study Area



Rahway River Basin, NJ

Flood Risk Management Feasibility Study

APPENDIX A-6

General Conformity and Greenhouse Gas Analysis

RECORD OF NON-APPLICABILITY (RONA)

Project Name: Rahway River Basin Flood Risk Management Study

Project/Action Point of Contact: Kimberly Rightler (Kimberly.a.rightler@usace.army.mil)

Estimated Begin Date: March 2020

Estimated End Date: July 2023

1. The project described above has been evaluated for Section 176 of the Clean Air Act. Project related emissions associated with the federal action were estimated to evaluate the applicability of General Conformity regulations (40CFR§93 Subpart B).

2. The project is located in Union and Essex Counties, New Jersey, which has the following nonattainment-related designations with respect to the National Ambient Air Quality Standards (40CFR§81.133; as of September 30, 2016): 'Moderate' Nonattainment 2008 8-hour Ozone Standard (primary and secondary) and 'Maintenance' for 2006 $PM_{2.5}$ Standard.

3. The requirements of this rule do not apply because the total direct and indirect emissions from this project are significantly less than the 100 tons trigger levels for NO_x, $PM_{2.5}$, and SO_2 for each project year and significantly below the 50 tons trigger level for VOC (40CFR§93.153(b)(1) & (2)), as VOCs, SO_2, and $PM_{2.5}$ are typically a fraction of total NOx emissions. The estimated emissions for the project for each pollutant are provided below.

Pollutant	Total Estimated Emissions
NOx	14.88
VOC	1.65
PM2.5	1.29
SO_2	0.01
CO	6.60

4. The project conforms with the General Conformity requirements (40CFR§93.153(c)(1)) and is exempted from the requires of 40 CFR §93 Subpart B.

Sincerely,

Chief, Planning Division

CLEAN AIR ACT GENERAL CONFORMITY APPLICABILITY AND GREENHOUSE GAS ANALYSIS AND EMISSIONS ESTIMATE FOR RAHWAY RIVER WATERSHED FLOOD RISK MANAGEMENT PROJECT, ESSEX AND UNION COUNTIES, NEW JERSEY

U.S. Army Corps of Engineers
New York District
26 Federal Plaza
New York, New York 10278-0090

September 2016

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ACRONYMS AND ABBREVIATIONS

CAA	Clean Air Act
CEQ	Council of Environmental Quality
CO	carbon monoxide
CO_2	carbon dioxide
EPA	U.S. Environmental Protection Agency
GCR	General Conformity Rule
GHG	Greenhouse Gas
MOVES	Motor Vehicle Emission Simulator
NAAQS	National Ambient Air Quality Standards
NO_2	nitrogen dioxide
NOx	nitrogen oxides
PM_{10} and $PM_{2.5}$	particulate matter
SIP	State Implementation Plan
SO_2	sulfur dioxide
VOC	volatile organic compounds

1.0 Introduction

1.1 Clean Air Act and General Conformity

The Project area is located in Union and Essex Counties, New Jersey, which are part of the New York, Northern New Jersey, Long Island, and Connecticut ozone nonattainment area. These counties have been designated with the following attainment status with respect to the National Ambient Air Quality Standards (NAAQS) for criteria pollutants: 'moderate' nonattainment area for the 2008 8-hour ozone standard, a maintenance area for the 1971 carbon dioxide (CO) standard, and a maintenance area for the 2006 particulate matter less than 2.5 microns ($PM_{2.5}$) standard (40 CFR §81.331). These counties are part of the Ozone Transport Region. Oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) are precursors for ozone, while sulfur dioxide (SO_2) (commonly reported as sulfur oxides (SO_x)) is a precursor pollutant for $PM_{2.5}$. Union and Essex Counties are in attainment of the NAAQS for all other criteria pollutants.

Emissions from the Project are associated with non-road construction equipment working on the site and on-road trucks moving on public roads to and from the Project site. Emissions from these two source categories, primarily generated from their diesel engines, include NO_x, VOCs, CO, SO_2, and $PM_{2.5}$. Emissions from Federal Actions, such as the Proposed Project, are regulated under 40 CFR §93 Subpart B General Conformity, which aims to ensure that emissions from Federal Actions to not impede a State's progress toward achieving or maintaining compliance with NAAQS under their applicable State Implementation Plan (SIP). Fugitive dust on the worksite can potentially be generated due to trucks and equipment moving on unpaved surfaces, but can be significantly reduced through the use of best management practices relating to site work dust mitigation.

1.2 Greenhouse Gas Emissions

In addition to the applicable regulated pollutants (Section 1.1), each Federal Agency project's NEPA assessment needs to consider and evaluate GHGs consistent with the Council on Environmental Quality (CEQ) guidance on the consideration of GHGs emissions and the effects of climate change.[1]

2.0 Emissions Analysis

The project will produce temporary localized emission increases from the diesel powered construction equipment working onsite. The localized emission increases from the diesel-powered equipment will last only during the project's construction period and then end when the project is over, thus any potential impacts will be temporary in nature.

As stated in Section 1.1, Union and Essex Counties have been designated with the following attainment status with respect to the NAAQS for criteria pollutants: 'moderate' nonattainment area for the 2008 8-hour ozone standard, and maintenance areas for CO and $PM_{2.5}$ standards. Ozone is controlled through the regulation of its precursor emissions, which include NO_x and VOCs. VOCs are emitted at a fractional rate compared to NOx emissions. SO_2 is a precursor for $PM_{2.5}$. Because of these designations and since the project is a Federal Action taken by the

[1] See *https://www.whitehouse.gov/administration/eop/ceq/initiatives/nepa/ghg-guidance*

USACE, this project triggers a General Conformity Review under 40 CFR §93.154. When conducting a General Conformity Review, emissions below specified annual thresholds are considered "de minimis" such that additional review or requirements are not needed. For the pollutants expected to be emitted by the project, the de minimis levels are: 100 tons of NO_x in any year, 50 tons of VOC in any year, 100 tons of CO in any year, 100 tons of $PM_{2.5}$ in any year), and 100 tons of SO_2 in any year).

The emissions associated with the project estimated as part of the General Conformity Review, and the relevant de minimis levels, are summarized below.

Construction Element	Source	Emissions (Ton)					
		VOC	NOx	CO	PM2.5	SO2	CO2
Reservoir	Nonroad Equipment	0.62	5.18	2.16	0.43	0.01	1306.24
	Highway Vehicle	0.44	3.82	1.32	0.28	0.00	471.13
Fish and Wildlife Facility	Nonroad Equipment	0.08	2.01	1.70	0.25	0.00	404.01
	Highway Vehicle	0.11	0.94	0.32	0.07	0.00	115.71
Channels and Canals	Nonroad Equipment	0.09	0.85	0.31	0.05	0.00	211.56
	Highway Vehicle	0.09	0.77	0.27	0.06	0.00	94.70
Nonstructural	Nonroad Equipment	0.18	0.84	0.33	0.15	0.00	194.50
	Highway Vehicle	0.04	0.47	0.20	0.01	0.00	112.23
Total		**1.65**	**14.88**	**6.60**	**1.29**	**0.01**	**2,911.36**
De Minimis Level		*50*	*100*	*100*	*100*	*100*	*n/a*
Will Emissions Exceed *De Minimis* Threshold		No	No	No	No	n/a	n/a

The Project's General Conformity-related emissions are significantly below all of the de minimis levels. Therefore, by rule (40 CFR §93.153 (b)), the Project is considered de minimis and will have only a temporary impact around the construction activities with no long-term impacts and no negative effects on the applicable SIP.

2.1 Greenhouse Gases

The 1 August 2016 CEQ Guidance 'does not establish a specific threshold for GHG emissions as "significantly" affecting the quality of the human environment or give greater consideration of the effects of GHG emissions and climate change over other effects of the human environment." However, the U.S. EPA published a rule in October 2009 outlining mandatory reporting of greenhouse gases from sources that in general emit 25,000 metric tons or more of carbon dioxide per year in the US. Smaller sources and certain sectors such as the agricultural sector and land use changes are not included in the Greenhouse Gas Reporting Program. As the emissions for the Proposed Action are well below the 25,000 metric tons threshold, mandatory reporting is not required. There will be no ongoing sources of GHG emissions resulting from the proposed action once construction is completed.

3.0 Emission Estimates

A construction estimate was made based on equipment type, size, and usage data and truck running hours provided by U.S. Army Corps of Engineers (USACE) in its equipment report based on TRACES MII Version 4.0 forecasts (August 15, 2016) for the four construction elements listed below:

- Reservoir.
- Fish and Wildlife Facility.
- Channels and Canals.
- Nonstructural Measures

3.1 Equipment Emissions

Estimates of equipment emissions for each element were based on the USACE-provided hours of usage and emission factors for each motorized source. Emission factors for each pollutant related to each equipment were predicted using the U.S. EPA's Motor Vehicle Emission Simulator (MOVES) MOVES2014a emission factor model (U.S. EPA, 2015) in association with the national default input parameters applicable for Union County, New Jersey.

The U.S. EPA recommends the following formula to calculate hourly emissions for the i^{th} pollutant from nonroad engine sources:

$$M_i = N \times HP \times EF_i$$

where:

M_i = mass of emissions of i^{th} pollutants during inventory period;
N = source population (units);
HP = average rated horsepower; and
EF_i = average emissions of i^{th} pollutant per unit of use (e.g., grams per horsepower-hour) predicted by MOVES2014a.

Estimated emissions from operation of nonroad equipment are presented in Tables 1 through 4 for each construction element, respectively.

3.2 Truck Emissions

MOVES2014a program was also used to predict on-road truck emission factors for both criteria pollutants and greenhouse gas. It was assumed that on an average, each truck would travel at a speed of 25 miles per hour. Estimated emissions from operation of trucks associated with each element are also presented in Tables 1 through 4.

4.0 Emissions Estimate Results

Tables 1-5 summarize the emissions analysis for the applicable NAAQS and for CO_2 as the primary Greenhouse Gas emission from construction and nonroad equipment.

5.0 References

Council on Environmental Quality. 1 August 2016. *Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews*.

U.S. Army Corps of Engineers, 2016. Equipment Report: *Rahway River Watershed Flood Risk Management Project* - *Alternative # 4A. August 15.*

U.S. EPA, 2015. Motor Vehicle Emission Simulator (MOVES) 2014a User Guide. December.

Table 1: Emissions from Reservoir Construction

Non Road Equipment	Hours	Horsepower (HP)	Emission Factors (grams/hp-hr)						Emissions (tons)					
			VOC	NOx	CO	PM2.5	SO2	CO2	VOC	NOx	CO	PM 2.5	SO2	CO2
AIR COMPRESSOR, 250 CFM	278	80	0.31	2.95	1.69	0.25	0.00	589.50	0.01	0.07	0.04	0.01	0.00	14.45
ASPHALT PAVER, SELF PROPELLED	2	115	0.21	1.89	0.80	0.18	0.00	536.25	0.00	0.00	0.00	0.00	0.00	0.14
CONCRETE PUMP, TRUCK MOUNTED	153	210	0.36	3.93	1.09	0.21	0.00	530.01	0.01	0.14	0.04	0.01	0.00	18.77
CONCRETE VIBRATOR, W/7.5 HP (5.6 KW) GENERATOR	610	8	0.81	5.31	4.55	0.52	0.00	588.02	0.00	0.03	0.02	0.00	0.00	2.97
CRANE, HYDRAULIC, TRUCK MOUNTED, 25 TON	6389	152	0.22	2.14	0.57	0.14	0.00	530.43	0.24	2.29	0.61	0.14	0.00	567.82
CRANE, HYDRAULIC, TRUCK MOUNTED, 90 TON	8	335	0.21	2.89	0.74	0.11	0.00	530.46	0.00	0.01	0.00	0.00	0.00	1.57
CRANE, MECHANICAL, LATTICE BOOM, CRAWLER, 60 TON	29	263	0.20	1.95	0.43	0.08	0.00	530.49	0.00	0.02	0.00	0.00	0.00	4.46
GRADER, 135 HP	21	135	0.20	1.67	0.73	0.17	0.00	536.28	0.00	0.01	0.00	0.00	0.00	1.68
HYDRAULIC EXCAVATOR, 1.75 CY BUCKET	720	168	0.19	1.49	0.65	0.15	0.00	536.31	0.03	0.20	0.09	0.02	0.00	71.51
LOADER, FRONT END, CRAWLER, 1.30 CY	21	140	0.88	4.79	4.63	0.64	0.00	693.46	0.00	0.01	0.01	0.00	0.00	1.12
LOADER, FRONT END, CRAWLER, 2.60 CY (2.0 M3) BUCKET	332	149	0.68	3.99	2.33	0.45	0.00	624.61	0.04	0.22	0.13	0.02	0.00	34.06
LOADER/BACKHOE, 0.80 CY	1809	60	0.88	4.79	4.63	0.64	0.00	693.46	0.10	0.57	0.55	0.08	0.00	82.97
PAVING BREAKER, 100 CFM COMPRESSOR	555	144	0.25	2.43	0.97	0.21	0.00	536.13	0.02	0.21	0.09	0.02	0.00	47.23
ROLLER, STATIC, SELF-PROPELLED, 14 TON	2	70	0.26	3.44	2.07	0.22	0.00	595.43	0.00	0.00	0.00	0.00	0.00	0.09
ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, 2.7 TON	3	33	0.21	3.64	0.80	0.12	0.00	595.56	0.00	0.00	0.00	0.00	0.00	0.06
ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, 6 TON	21	70	0.26	3.44	2.07	0.22	0.00	595.43	0.00	0.01	0.00	0.00	0.00	0.96
TRACTOR, CRAWLER (DOZER), 101-135 HP	3813	135	0.20	1.70	0.74	0.17	0.00	536.28	0.11	0.97	0.42	0.10	0.00	304.30
TRACTOR, CRAWLER (DOZER), 181-250 HP	1029	250	0.19	1.55	0.52	0.10	0.00	536.31	0.05	0.44	.015	0.03	0.00	152.08
TOTAL									0.62	5.18	2.16	0.43	0.00	1,306.24
Highway Vehicle	**Hours**		**Emission Factors (grams/hp-hr)**						**Emissions (tons)**					
			VOC	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**	**VOC**	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**
DUMP TRUCK, HIGHWAY, 16 - 20 CY, DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	73		0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.02	0.01	0.00	0.00	2.74

DUMP TRUCK, HIGHWAY, 10 - 13 CY, DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	12,382	0.07	0.61	0.21	0.04	0.00	75.16	0.44	3.78	1.30	0.28	0.00	465.31
TRUCK, HIGHWAY, 35,000 LB (15,876 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)	61	0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.02	0.01	0.00	0.00	2.29
TRUCK, HIGHWAY, 50,000 LB (22,680 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)	21	0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.01	0.00	0.00	0.00	0.79
Total								0.09	0.77	0.27	0.06	0.00	471.13
Total Emission								0.18	1.61	0.57	0.11	0.00	1,777.38

Table 2: Emissions from Fish and Wildlife Facility Construction

Non Road Equipment	**Hours**	**Horsepower (HP)**	**Emission Factors (grams/hp-hr)**						**Emissions (tons)**					
			VOC	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**	**VOC**	**NOx**	**CO**	**PM 2.5**	**SO2**	**CO2***
HYDRAULIC EXCAVATOR, CRAWLER, 70,000 LB	243	222	0.18	1.34	0.44	0.08	0.00	536.34	0.01	0.08	0.03	0.00	0.00	31.89
LOADER, FRONT END, 3.50 CY	284	180	0.68	3.99	2.33	0.45	0.00	624.61	0.04	0.24	0.14	0.03	0.00	37.14
LOADER/BACKHOE, 0.80 CY	323	60	0.88	4.79	4.63	0.64	0.00	693.46	0.02	1.14	1.10	0.15	0.00	164.95
TRACTOR, CRAWLER (DOZER), 101-135 HP	57	135	0.20	1.70	0.74	0.17	0.00	536.28	0.00	0.10	0.04	0.01	0.00	31.89
TRACTOR, CRAWLER (DOZER), 181-250 HP	87	250	0.19	1.55	0.52	0.10	0.00	536.31	0.00	0.09	0.03	0.01	0.00	31.89
TRACTOR, CRAWLER (DOZER), 50-75 HP	248	75	0.22	2.03	2.01	0.26	0.00	595.55	0.00	0.36	0.36	0.05	0.00	106.24
TOTAL									0.08	2.01	1.70	0.25	0.00	404.01
Highway Vehicle	**Hours**		**Emission Factors (grams/hp-hr)**						**Emissions (tons)**					
			VOC	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**	**VOC**	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**
DUMP TRUCK, HIGHWAY, 10 - 13 CY, DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	2,905		0.07	0.61	0.21	0.04	0.00	75.16	0.10	0.89	0.31	0.06	0.00	109.17
DUMP TRUCK, HIGHWAY, 16 - 20 CY, DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	174		0.07	0.61	0.21	0.04	0.00	75.16	0.01	0.05	0.02	0.00	0.00	6.54
Total									0.11	0.94	0.32	0.07	0.00	115.71
Total Emission									0.19	2.95	2.02	0.31	0.00	519.72

Table 3: Emissions from Channels and Canals Construction

Non Road Equipment	Hours	Horsepower (HP)	Emission Factors (grams/hp-hr)						Emissions (tons)					
			VOC	NOx	CO	PM2.5	SO2	CO2	VOC	NOx	CO	PM 2.5	SO2	CO2
AIR COMPRESSOR, 100 CFM	138	49	0.23	3.85	0.91	0.15	0.00	589.71	0.00	0.03	0.01	0.00	0.00	4.40
CONCRETE VIBRATOR, W/7.5 HP (5.6 KW) GENERATOR	75	8	0.81	5.31	4.55	0.52	0.00	588.02	0.00	0.00	0.00	0.00	0.00	0.36
CRANE, HYDRAULIC, TRUCK MOUNTED, 90 TON	2	335	0.21	2.89	0.74	0.11	0.00	530.46	0.00	0.00	0.00	0.00	0.00	0.39
CRANE, MECHANICAL, LATTICE BOOM, CRAWLER, 60 TON	629	263	0.20	1.95	0.43	0.08	0.00	530.49	0.04	0.35	0.08	0.01	0.00	95.29
GRADER, 135 HP	48	135	0.20	1.67	0.73	0.17	0.00	536.28	0.00	0.01	0.01	0.00	0.00	3.83
LOADER, FRONT END, CRAWLER, 2.00 CY	37	121	0.68	3.99	2.33	0.45	0.00	624.61	0.00	0.02	0.01	0.00	0.00	3.08
LOADER/BACKHOE, 0.80 CY	37	60	0.88	4.79	4.63	0.64	0.00	693.46	0.00	0.01	0.01	0.00	0.00	1.70
LOADER/BACKHOE, 1.25 CY	75	90	0.93	4.28	5.29	0.74	0.00	693.32	0.01	0.03	0.04	0.01	0.00	5.16
PAVING BREAKER, 66 LB, 100 CFM COMPRESSOR	275	144	0.25	2.43	0.97	0.21	0.00	536.13	0.01	0.11	0.04	0.01	0.00	23.40
PILE HAMMER, DRIVER/EXTRACTOR, VIBRATORY, 80 TON	29	325	0.31	4.19	1.25	0.18	0.00	530.15	0.00	0.04	0.01	0.00	0.00	5.51
ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, 6 TON	10	70	0.26	3.44	2.07	0.22	0.00	595.43	0.00	0.00	0.00	0.00	0.00	0.46
ROLLER, VIBRATORY, SELF-PROPELLED, SINGLE DRUM, 12 TON	39	153	0.22	2.04	0.85	0.19	0.00	536.22	0.00	0.01	0.01	0.00	0.00	3.53
ROLLER, VIBRATORY, TOWED, SINGLE DRUM, 25.5 TON	347	50	0.26	3.44	2.07	0.22	0.00	595.43	0.00	0.07	0.04	0.00	0.00	11.39
TRACTOR, CRAWLER (DOZER), 181-250 HP	347	250	0.19	1.55	0.52	0.10	0.00	536.31	0.02	0.15	0.05	0.01	0.00	51.29
TRACTOR, CRAWLER (DOZER), 251-300 HP	10	300	0.19	2.22	0.89	0.12	0.00	536.32	0.00	0.01	0.00	0.00	0.00	1.77
TOTAL									0.09	0.85	0.31	0.05	0.00	211.56
Highway Vehicle	**Hours**		**Emission Factors (grams/hp-hr)**						**Emissions (tons)**					
			VOC	NOx	CO	PM2.5	SO2	CO2	VOC	NOx	CO	PM2.5	SO2	CO2
TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)	48		0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.01	0.01	0.00	0.00	1.80
DUMP TRUCK, HIGHWAY, 10 - 13 CY, DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	2,387		0.07	0.61	0.21	0.04	0.00	75.16	0.08	0.73	0.25	0.05	0.00	89.70
TRUCK, HIGHWAY, 35,000 LB (15,876 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)	75		0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.02	0.01	0.00	0.00	2.82

TRUCK, HIGHWAY, 50,000 LB (22,680 KG) GVW, 6X4, 3 AXLE (ADD ACCESSORIES)	10	0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.00	0.00	0.00	0.00	0.38
Total								0.09	0.77	0.27	0.06	0.00	94.70
Total Emission								0.18	1.61	0.57	0.11	0.00	306.26

Table 4: Emissions from Nonstructural Measures

Non Road Equipment	Hours	Horsepower (HP)	Emission Factors (grams/hp-hr)*						Emissions (tons)					
			VOC	NOx	CO	PM2.5	SO2	CO2	VOC	NOx	CO	PM 2.5	SO2	CO2
AIR COMPRESSOR, 250 CFM	181	80	0.31	2.95	1.69	0.25	0.00	589.50	0.00	0.02	0.02	0.00	0.00	9.05
CONCRETE PUMP, TRUCK MOUNTED	75	210	0.36	3.93	1.09	0.21	0.00	530.01	0.00	0.05	0.01	0.00	0.00	9.0
CONCRETE VIBRATOR, W/7.5 HP (5.6 KW) GENERATOR	15	8	0.81	5.31	4.55	0.52	0.00	588.02	0.00	0.00	0.00	0.00	0.00	0.07
GRADER, 135 HP	21	135	0.20	1.67	0.73	0.17	0.00	536.28	0.00	0.00	0.00	0.00	0.00	0.08
LOADER, FRONT END, CRAWLER, 1.30 CY	570	140	0.88	4.79	4.63	0.64	0.00	693.46	0.01	0.07	0.01	0.01	0.00	30.04
LOADER, FRONT END, CRAWLER, 2.60 CY (2.0 M3) BUCKET	395	149	0.68	3.99	2.33	0.45	0.00	624.61	0.00	0.04	0.05	0.01	0.00	40.52
LOADER/BACKHOE, 0.80 CY	350	60	0.88	4.79	4.63	0.64	0.00	693.46	0.10	0.02	0.04	0.08	0.00	16.05
ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, 2.7 TON	300	33	0.21	3.64	0.80	0.12	0.00	595.56	0.00	0.03	0.02	0.00	0.00	6.0
ROLLER, VIBRATORY, SELF-PROPELLED, DOUBLE DRUM, 6 TON	150	70	0.26	3.44	2.07	0.22	0.00	595.43	0.00	0.03	0.02	0.00	0.00	6.85
TRACTOR, CRAWLER (DOZER), 101-135 HP	500	135	0.20	1.70	0.74	0.17	0.00	536.28	0.02	0.21	0.09	0.02	0.00	39.90
TRACTOR, CRAWLER (DOZER), 181-250 HP	250	250	0.19	1.55	0.52	0.10	0.00	536.31	0.05	0.44	0.15	0.03	0.00	36.94
TOTAL									0.18	0.84	0.33	0.15	0.00	194.50
Highway Vehicle	**Hours**		**Emission Factors (grams/hp-hr)**						**Emissions (tons)**					
			VOC	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**	**VOC**	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**
DUMP TRUCK, HIGHWAY, 16 - 20 CY, DUMP BODY, 75,000 LBS (34,000 KG) GVW, 2 AXLE, 6X4	40		0.07	0.61	0.21	0.04	0.00	75.16	0.00	0.01	0.00	0.00	0.00	1.50
DUMP TRUCK, HIGHWAY, 10 - 13 CY, DUMP BODY, 35,000 LBS (15,900 KG) GVW, 2 AXLE, 4X2	1,400		0.07	0.61	0.21	0.04	0.00	75.16	0.02	0.22	0.10	0.00	0.00	54.87
TRUCK, HIGHWAY, 45,000 LB (20,412 KG) GVW, 6X4, 3 AXLE	1,488		0.07	0.61	0.21	0.04	0.00	75.16	0.02	0.24	0.10	0.01	0.00	55.86
Total									0.04	0.47	0.20	0.01	0.00	112.23
Total Emission									0.22	1.31	0.53	0.16	0.00	306.73

Table 5: Total Combined Construction Emissions

Construction Element	Source	Emissions (Ton)					
		VOC	**NOx**	**CO**	**PM2.5**	**SO2**	**CO2**
Reservoir	Nonroad Equipment	0.62	5.18	2.16	0.43	0.01	1306.24
	Highway Vehicle	0.44	3.82	1.32	0.28	0.00	471.13
Fish and Wildlife Facility	Nonroad Equipment	0.08	2.01	1.70	0.25	0.00	404.01
	Highway Vehicle	0.11	0.94	0.32	0.07	0.00	115.71
Channels and Canals	Nonroad Equipment	0.09	0.85	0.31	0.05	0.00	211.56
	Highway Vehicle	0.09	0.77	0.27	0.06	0.00	94.70
Nonstructural	Nonroad Equipment	0.18	0.84	0.33	0.15	0.00	194.50
	Highway Vehicle	0.04	0.47	0.20	0.01	0.00	112.23
Total		**1.65**	**14.88**	**6.60**	**1.29**	**0.01**	**2,911.36**
De Minimis Level		*50*	*100*	*100*	*100*	*n/a*	*n/a*
Will Emissions Exceed *De Minimis* Threshold		No	No	No	No	n/a	n/a

Draft Appendix B

Economics

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

Rahway River Basin, New Jersey

Flood Risk Management Feasibility Study

Appendix B – Economics

Contents

6.0 Comparison of Alternatives

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1.0 Introduction

This report was prepared to document procedures and results of the economic flood damage analysis for the Rahway River Basin, New Jersey Flood Risk Management Feasibility Study. This report presents the findings of economic damage assessments for the municipalities of Cranford, Kenilworth, Springfield, Union, and Millburn along the Rahway River and the City of Rahway along the Robinsons Branch

Economic analyses include the development of stage versus damage relationships and annual damages over a 50-year analysis period, from year 2023 to year 2073. Damage assessments include inundation damages to structure and contents and vehicles.

Estimates of without-project damages and with-project damages are based on October 2015 price levels and a 50-year period of analysis, damages have been annualized over the 50-year project life using the 2016 fiscal year Federal water resource studies discount rate of 3.125%.

For the purposes of this report, the analysis is divided into two areas, Cranford/Upstream covering municipalities of Cranford, Kenilworth, Springfield, Union, Milburn, and Robinson's Branch covering the City of Rahway.

2.0 Description of Study Area

2.1 Location and Setting

The Rahway River Basin is located in northeastern New Jersey. It lies within the metropolitan area of Greater New York City and occupies approximately 15 percent of Essex County, 35 percent of Union County, and 10 percent of Middlesex County. The basin is 83.3 square miles (53,300 acres) in area and is roughly crescent-shaped. Its greatest width is approximately 10 miles in the east-west direction, from the City of Linden to the City of Plainfield. Its greatest length is approximately 18 miles in a north–south direction, from West Orange to Metuchen. The tidal influence on the Rahway River extends roughly 5 miles from the Arthur Kill into the City of Rahway.

The Rahway River consists of the mainstem Rahway River and four branches. The West Branch flows south from West Orange through South Mountain Reservation and downtown Millburn. The East Branch also originates in West Orange and Montclair and travels through South Orange and Maplewood. These two branches converge near Route 78 in Springfield to form the mainstem of the Rahway River. The Rahway River flows through the municipalities of Springfield, Union, Cranford and Clark before traveling through the City of Rahway. The Rahway River receives the waters of Robinson's Branch at Elizabeth Avenue between West Grand Avenue and West Main Street and the waters of the South Branch at East Hazelwood Avenue and Leesville Avenue before it leaves the City of Rahway and enters the city limits of Linden and Carteret. The Rahway River then flows into the Arthur Kill. Figure 1 below shows the Rahway River Basin/Study Area.

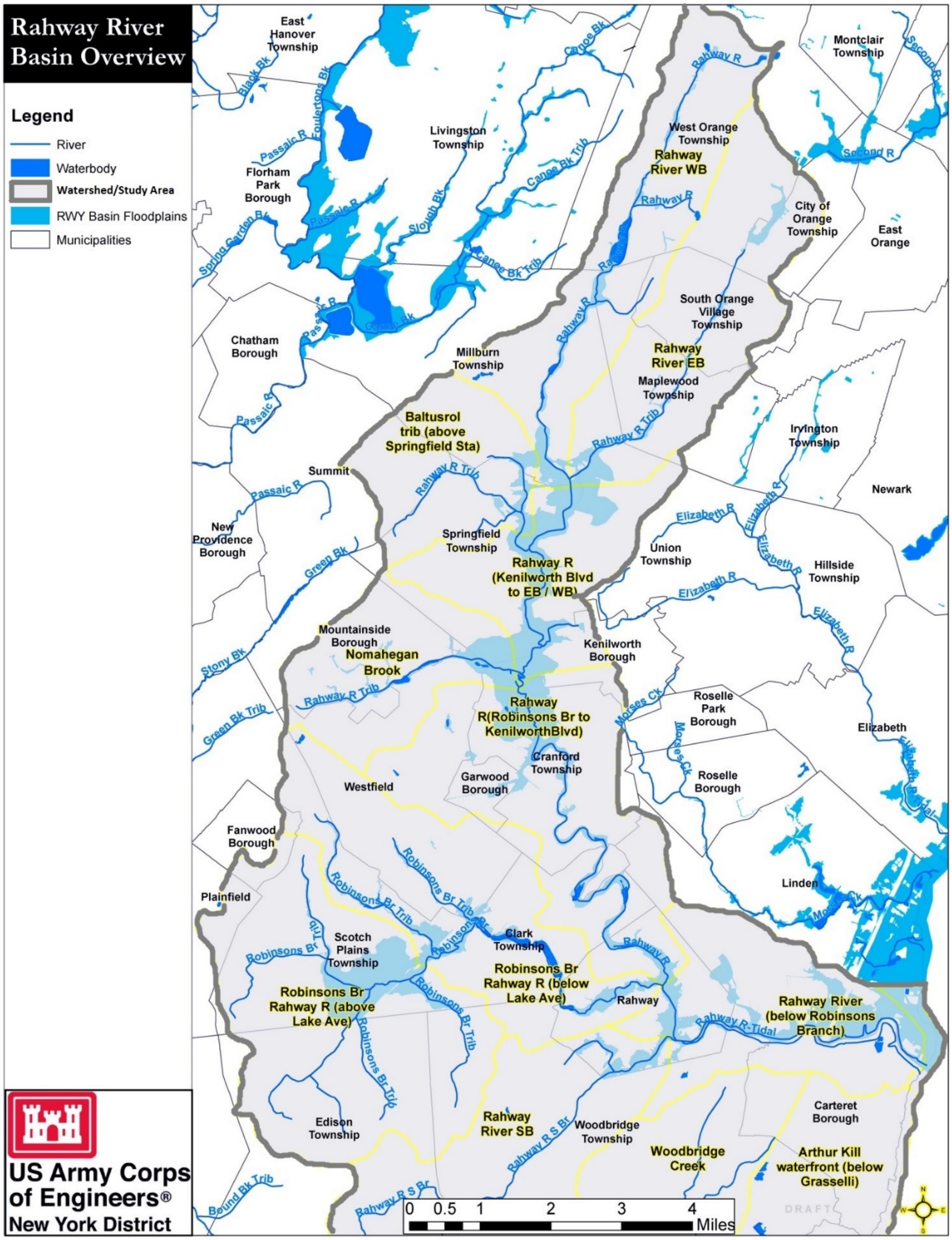

Figure 1. Rahway River Basin/Study Area

2.2 Demographics and Land Use

2.2.1 Township of Cranford

The Township of Cranford has a total area of 4.87 square miles and is located in central Union County, New Jersey. Major transportation routes passing through Cranford include Route 28 and the Garden State Parkway, as well as a NJ Transit Rail Line, including a commuter station. The 2010 U.S. Census listed the Township of Cranford's population as 22,625, reflecting an increase of 47 (+0.2%) from the 22,578 counted in the 2000 U.S. Census. Population under age 5 is 5.7% and 65years and over is 17.2% (US Census 2010). The racial makeup is 86.8% white, 6.8% Hispanic, 2.8% Asian, and 2.5% black (US Census 2014). The median household income is $116,276, and the per capita income is $48,943. The three predominant occupations are management, business, science, and arts (52.7%), sales and office (25.4%), and service (11.6%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 2.2% of the township as below the poverty line. Land use is summarized in Table 1.

2.2.2 Borough of Kenilworth

The Borough of Kenilworth has a total area of 2.161 square miles and is located between Routes 22 and 28 in Union County, New Jersey. The 2010 U.S. Census listed the Township of Cranford's population as 7,914, reflecting an increase of 239 (+3.11%) from the 7,675 counted in the 2000 U.S. Census. Population under age 5 is 5.1% and 65years and over is 15.6% (US Census 2010). The racial makeup is 86.8% white, 6.5% Hispanic, 2.8% Asian, and 2.5% black. (US Census 2014). The median household income is $100,680, and the per capita income is $41,792. The three predominant occupations are sales and office (33.7%), management, business, science, and arts (32.6%), and service (15.9%) (US Census 2014). The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 5.3% of the city as below the poverty line. Land use is summarized in Table 1.

2.2.3 City of Rahway

The City of Rahway has a total area of 4.03 square mile and is located in southeastern Union County, New Jersey. Major transportation routes in Rahway include Route 1 and Route 27, and there is a railway station for the NJ Transit Northeast Corridor line. The 2010 U.S. Census listed the City of Rahway's population as 27,346, reflecting an increase of 846 (+3.2%) from the 26,500 counted in the 2000 U.S. Census. Population under 5 years is 5.9%, and 65 years and over is 13.5% (US Census 2010). The racial makeup is 40.3% white, 29.6% black, 23.5% Hispanic and 4.2% Asian (US Census, 2014). The median household income is $59,076, and the per capita income is $28,994. The three predominant occupations are management, business, science, and arts (33.9%), sales and office (30%), and service (17.2%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 9.6% of the city as below the poverty line. Land use is summarized in Table 1.

2.2.4 Township Of Springfield

The Township of Springfield has a total area of 5.2 square miles and is located along the northern border of Union County, New Jersey. Major thoroughfares include Interstate 78, Route 28 and Route 22. The 2010 U.S. Census listed the Township of Springfield's population as 15,817, reflecting an increase of 1,388 (+9.6%) from the 14,429 counted in the 2000 U.S. Census. Population under 5 years is 6.0%, and 65 years and over is 14.7% (US Census 2010). The racial makeup is 75.4% white, 9.6% Hispanic, 7.6% Asian, 6.1% black (US Census, 2014). The median household income is $100,461, and the per capita income is $50,478. The three predominant occupations are management, business, science, and arts (54.3%), sales and office (27.9%), and service (7.3%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 5.2% of the township as below the poverty line. Land use is summarized in Table 1.

2.2.5 Township of Union

The township of Union has a total area of 9.09 square miles and is located in northern Union County, New Jersey. Major transportation elements include Routes 22 and 82, Interstate 78, the Garden State Parkway and a NJ Transit rail station. The 2010 U.S. Census listed the Township of Union's population as 56,642, reflecting an increase of 2,237 (+4.1%) from the 54,405 counted in the 2000 U.S. Census. Population under 5 years is 5.4%, and 65 years and over is 14% (US Census 2010). The racial makeup is 44.1% white, 28.2% black, 14.9% Hispanic and 10.5% Asian (US Census, 2014). The median household income is $73,249, and the per capita income is $33,405. The three predominant occupations are management, business, science, and arts (41.9%), sales and office (26.4%), and service (15.4%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 7.9% of the city as below the poverty line. Land use is summarized in Table 1.

2.2.6 Township of Millburn.

The township of Millburn has a total area of 9.876 square miles and is located in southwestern Essex County, New Jersey. Major transportation routes include Routes 24, 124 and Interstate 78, and there are two NJ Transit Rail Line commuter stations. The 2010 U.S. Census listed the Township of Millburn's population as 20,149, reflecting an increase of 384 (+1.9%) from the 19,765 counted in the 2000 U.S. Census. Population under 5 years is 6.2%, and 65 years and over is 11.3% (US Census 2010). The racial makeup is 77.4% white, 15.6% Asian, 3.5% Hispanic, and 1.5% black (US Census 2014). The median household income is $165,944, and the per capita income is $48,943. The three predominant occupations are management, business, science, and arts (68.0%), sales and office (21.1%), and service (7.7%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 3.1% of the township as below the poverty line. Land use is summarized in Table 2.

2.2.7 Township of West Orange

The Township of West Orange has a total area of 12.171 square miles and is located in central Essex County, New Jersey. Major transportation elements include Interstate 78, and the Garden State Parkway. The 2010 U.S. Census listed the Township of West Orange's population as 46,207, reflecting an increase of 1,264 (+2.8%) from the 44,943 counted in the 2000 U.S. Census. Population under 5 years is 6.6%, and 65 years and over is 15.9% (US Census 2010). The racial makeup is 57.1% white, 26.6% black, 16.2% Hispanic and 8.0% Asian (US Census, 2010). The median household income is $90,031, and the per capita income is $43,670. The three predominant occupations are management, business, science, and arts (47.1%), sales and office (24.1%), and service (15.2%) (US Census 2014).The U.S. Census 2010-2014 American Community Survey 5-Year Estimates lists 6.1% of the city as below the poverty line.

Table 1. Union County Land Use for Selected Municipalities

Union County Land Use (NJDEP GIS, 2007)										
	Rahway City		Cranford Township		Kenilworth Borough		Springfield Township		Union Township	
Land Cover Class	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Agriculture	0	0%	6.29	0.20%	0%	0%	18.66	0.56%	0	0%
Barren Land	43.32	1.67%	9.52	0.31%	0	0%	108.46	3.28%	6.49	0.11%
Forest	72.21	2.79%	260.64	8.36%	124.95	9.08%	554.74	16.77%	405.77	6.98%
Urban	2298.78	88.86%	2613.87	83.85%	1210.47	87.93%	2432.94	73.55%	5117.59	88.06%
Water	88.95	3.44%	57.22	1.84%	8.11	0.59%	25.6	0.77%	33.4	0.58%
Wetlands	82.92	3.21%	169.95	5.45%	33.15	2.41%	167.49	5.06%	247.89	4.27%

Table 2. Millburn Township Land Use

Land Use of Millburn Township (NJPEP GIS 2007)		
Land Use Class	Acres	Percent of Total
Agriculture	3.91	0.06%
Cemetery	10.78	0.17%
Commercial Services	374.69	5.92%
Forest	1481.24	23.42%
Other Urban or Altered Land	72.42	1.15%
Recreational Land	438.59	6.93%
Residential	2914.58	46.08%
Transportation/Communications/Utilities	198.94	3.15%
Water	357.79	5.66%
Wetlands	471.54	6.60%

3.0 Problem Identification

3.1 Historical Flood Events

Storm events in the Rahway River Basin which caused significant damage are the storms of July 1938, May 1968, August 1971, August 1973, November 1977, July 1979, June 1992, October 1996, July 1997, Tropical Storm Floyd in September 1999, April 2007 and Tropical Storm Irene in August 2011.

Tropical Storm Floyd

Rainfall totals from Tropical Storm Floyd in September 1999 were as high as 12 to 16 inches over portions of New Jersey, 4 to 8 inches over southeastern New York, and up to 11 inches over portions of New England. Tropical Storm Floyd resulted in new flood peaks of record at sixty or more stream gages within the portions of New Jersey and New York contained by New York District's Civil Works boundaries. Within the Rahway River basin, the total rainfall at Cranford, NJ was 10.82 inches. This resulted in flows approaching the 100 year level in portions of the Rahway River Basin.

April 2007 Northeaster

The April 2007 northeaster caused about three to ten inches of rain to fall on the watersheds within the New York District's Civil Works boundaries in April 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey. The approximate rainfall of the total rainfall of the April 2007 northeaster over the watersheds of the New York District was an average of 7 to 7 ½ inches. Within the Rahway River basin, the total rainfall at Cranford was 6.47 inches. This resulted in flows from greater than the 25 to greater than the 50 year level in portions of the Rahway River Basin.

Tropical Storm Irene

Tropical Storm Irene began as a tropical wave off the West African coast on 15 August 2011. Tropical Storm Irene had weakened to a tropical storm with winds of 65 mph by the time of its 18 August New York landfall.

Significant damages occurred in north and central New Jersey, where flooding was widespread. Severe flooding took place on the Raritan, Millstone, Rockaway, Rahway, Delaware and Passaic Rivers due to record rainfall. The flooding affected roads and ten deaths within the state are attributable to the storm.

In addition to major flooding, the combination of already heavily saturated ground from a wet summer, and heavy wind gusts made New Jersey especially vulnerable to wind damage. One of the hardest hit areas due to high winds was Union County, part of the Rahway River Basin. Fallen trees, many pushed from the soaked ground with their roots attached, blocked vital roads from being accessed by local emergency services. Numerous homes suffered structural damages from the winds, and limbs impacting their roofs. Perhaps the most critical damage however due to wind was fallen wires. Around Union County, fallen wires in combination with flooded electrical substations left parts of Union County, including Cranford, Garwood, and Westfield without power or phone service for nearly a week. In total, approximately 1.46 million customers of Jersey Central Power & Light (JCP&L) and Public Service Enterprise Group (PSEG) throughout most of the 21 counties lost power.

4.0 Without-Project Condition

4.1 General

Periodic storms have caused severe fluvial flooding along the Rahway River. There are two main areas with high flood risk, the Township of Cranford and the Robinsons Branch in Rahway. Flooding along the Rahway River at Cranford is caused by low channel capacity, constrictions of several bridges and dams along the river and two 90 degree bends forming a “U” turn at the Springfield Ave. just upstream of the center of the Township. The flood waters backup from the main Cranford area into the area of Lenape Park Detention Basin and Kenilworth Township. In City of Rahway at Robinson’s Branch the high risk of flooding is due to low channel capacity, the constrictions of several bridges, and the backwater from the main stem of the Rahway River, which is independent of the hydraulic conditions in the Robinson’s Branch.

4.2 Flood Damages

4.2.1 Delineation of Project Reaches

The study area has been divided into two areas for the economic analysis: Cranford Upstream, for the municipalities of Cranford, Kenilworth, Springfield, Union, Milburn, and Robinson’s Branch, for the City of Rahway.

Cranford Upstream: In order to conduct economic damage analyses for the without-project condition and alternative plans, Cranford has been divided into three streams containing a total of 61 economic reaches. The left bank of the Rahway River through the study area contains 29 reaches, while the right bank contains 32 reaches. Streams, reach locations and the upstream and downstream limits of the reaches in the economic model were selected to be consistent with the hydrologic/hydraulic modeling and were mostly located at the location of bridges, existing levees, and hydraulic structures such as dams, so that the effects of these features could be modeled in detail. A summary of the economic reaches is presented in Table 3.

Table 3
Summary of Economic Reaches (Cranford Upstream)

Stream	Reach	Bank	D/S Station	U/S Station	Index Station	Municipality
Lower	LCL1	Left	0	2000	1000	Cranford
Lower	LCR1	Right	0	2000	1000	Cranford
Lower	LCL2	Left	2000	2219	2100	Cranford
Lower	LCR2	Right	2000	2219	2100	Cranford
Cran-Spring	UCL1	Left	0	1770	1266	Cranford
Cran-Spring	UCR1	Right	0	1770	1266	Cranford
Cran-Spring	UCL2	Left	1770	2351	1988	Cranford
Cran-Spring	UCR2	Right	1770	2351	1988	Cranford

Table 3						
Summary of Economic Reaches (Cranford Upstream)						
Cran-Spring	UCL3	Left	2351	3249	2942	Cranford
Cran-Spring	UCR3	Right	2351	3249	2942	Cranford
Cran-Spring	UCL4	Left	3250	4857	4262	Cranford
Cran-Spring	UCR4	Right	3250	4857	4262	Cranford
Cran-Spring	UCL5	Left	4857	8480	6959	Cranford
Cran-Spring	UCR5	Right	4857	8357	6959	Cranford
Cran-Spring	UCR6	Right	8357	9658	8977	Cranford
Cran-Spring	UCR7	Right	9658	11424	10227	Cranford
Cran-Spring	UCL6	Left	8480	15019	11026	Cranford
Cran-Spring	UCR8	Right	11424	15289	13280	Cranford
Cran-Spring	UCL7	Left	15019	15289	15019	Cranford
Cran-Spring	UCL8	Left	15289	15452	15365	Kenilworth
Cran-Spring	UCR9	Right	15289	15452	15365	Cranford
Cran-Spring	UCR10	Right	15452	17352	17010	Springfield
Cran-Spring	UCL9	Left	15452	20268	17352	Kenilworth
Cran-Spring	UCR10A	Right	17352	18448	17943	Springfield
Cran-Spring	UCR11	Right	18448	21641	19072	Springfield
Cran-Spring	UCL12	Left	20268	22865	21991	Union
Cran-Spring	UCR12	Right	21641	22865	21991	Springfield
Cran-Spring	UCL13	Left	22865	23180	23180	Union
Cran-Spring	UCR13	Right	22865	23180	23180	Springfield
Cran-Spring	UCL14	Left	23180	26037	24745	Union
Cran-Spring	UCR14	Right	23180	26037	24745	Springfield
Cran-Spring	UCL15	Left	26037	30195	27765	Union
Cran-Spring	UCR15	Right	26037	30195	27765	Springfield
Cran-Spring	UCL16	Left	30195	31870	31365	Union
Cran-Spring	UCR16	Right	30195	31870	31365	Springfield
Cran-Spring	UCL17	Left	31870	34471	33460	Union
Cran-Spring	UCR17	Right	31870	34471	33460	Springfield
Cran-Spring	UCL18	Left	34471	36488	35513	Union
Cran-Spring	UCR18	Right	34471	36488	35513	Springfield
Cran-Spring	UCL19	Left	36488	37729	36895	Union
Cran-Spring	UCR19	Right	36488	37729	36895	Springfield
Millburn	ML20L	Left	37729	39281	38724	Millburn
Millburn	ML20R	Right	37729	39281	38724	Millburn
Millburn	ML21L	Left	39281	39419	39419	Millburn
Millburn	ML21R	Right	39281	39419	39419	Millburn
Millburn	ML22L	Left	39419	39577	39495	Millburn
Millburn	ML22R	Right	39419	39577	39495	Millburn

Table 3						
Summary of Economic Reaches (Cranford Upstream)						
Millburn	ML23L	Left	39577	40590	40234	Millburn
Millburn	ML23R	Right	39577	40590	40234	Millburn
Millburn	ML24L	Left	40590	41010	40720	Millburn
Millburn	ML24R	Right	40590	41010	40720	Millburn
Millburn	ML25L	Left	41010	41475	41193	Millburn
Millburn	ML25R	Right	41010	41475	41193	Millburn
Millburn	ML26L	Left	41475	41896	41805	Millburn
Millburn	ML26R	Right	41475	41896	41805	Millburn
Millburn	ML27L	Left	41896	42075	42021	Millburn
Millburn	ML27R	Right	41896	42075	42021	Millburn
Millburn	ML28L	Left	42075	42320	42150	Millburn
Millburn	ML28R	Right	42075	42320	42150	Millburn
Millburn	ML29L	Left	42320	42670	42350	Millburn
Millburn	ML29R	Right	42320	42670	42350	Millburn

Robinson’s Branch: The Robinson’s Branch study area has been divided into two sections to enable analysis for the area of the Rahway River and Robinson’s Branch that has fluvial and tidal effects and the second area that only has fluvial effects. The section that has fluvial and tidal effects is divided into 25 economic reaches. The left bank of the Rahway River through this fluvial/tidal area contains 5 reaches and the right bank contains 5 reaches. The Robinson’s Branch has 7 reaches on the left bank and 8 reaches on the right bank. A summary of the economic reaches is presented in Table 4.
The section that only has fluvial effects is divided into 30 economic reaches. The left bank of the Rahway River through this fluvial/tidal area contains 5 reaches and the right bank contains 5 reaches. The Robinson’s Branch has 10reaches on the left bank and 10 reaches on the right bank. A summary of the economic reaches is presented in Table 4a.

Streams, reach locations and the upstream and downstream limits of the reaches in the economic models were selected to be consistent with the hydrologic/hydraulic modeling.

Table 4						
Summary of Economic Reaches (Robinson's Branch Fluvial/Tidal Influence)						
Stream	**Reach**	**Bank**	**D/S Station**	**U/S Station**	**Index Station**	**Municipality**
Millburn-Clark	M1-L	Left	28472.8	30053.46	29222.75	Rahway
Millburn-Clark	M1-R	Right	28472.8	30053.46	29222.75	Rahway
Millburn-Clark	M2-L	Left	30053.5	32915.6	31664.2	Rahway
Millburn-Clark	M2-R	Right	30053.5	32915.6	31664.2	Rahway
Millburn-Clark	M3-L	Left	32915.7	35000.56	33838.3	Rahway
Millburn-Clark	M3-R	Right	32915.7	35000.56	33838.3	Rahway
Rahway	R1-L	Left	24509.3	27042	25641.5	Rahway
Rahway	R1-R	Right	24509.3	27042	25641.5	Rahway
Rahway	R2-L	Left	27042.1	28472.7	27559	Rahway
Rahway	R2-R	Right	27042.1	28472.7	27559	Rahway
Robinsons Branch	RB1-L	Left	175.4	777.8	450	Rahway
Robinsons Branch	RB1-R	Right	175.4	721.8	450	Rahway
Robinsons Branch	RB2-L	Left	777.9	2535.375	1725	Rahway
Robinsons Branch	RB2.1-R	Right	721.89	880.706	777.86	Rahway
Robinsons Branch	RB2.2-R	Right	880.8	2535.375	1725	Rahway
Robinsons Branch	RB3-L	Left	2335.4	3945.5	3334	Rahway
Robinsons Branch	RB3-R	Right	2335.4	3945.5	3334	Rahway
Robinsons Branch	RB4-L	Left	3945.55	5282.545	4434.81	Rahway
Robinsons Branch	RB4-R	Right	3945.55	5282.545	4434.81	Rahway
Robinsons Branch	RB5-L	Left	5282.6	6760.3	6358	Rahway
Robinsons Branch	RB5-R	Right	5282.6	6760.3	6358	Rahway
Robinsons Branch	RB6-L	Left	6760.4	7752.9	7463	Rahway
Robinsons Branch	RB6-R	Right	6760.4	7752.9	7463	Rahway
Robinsons Branch	RB7-L	Left	7753	8840.2	8345	Rahway
Robinsons Branch	RB7-R	Right	7753	8840.2	8345	Rahway

Table 4a						
Summary of Economic Reaches (Robinson's Branch Fluvial Influence)						
Stream	**Reach**	**Bank**	**D/S Station**	**U/S Station**	**Index Station**	**Municipality**
Millburn-Clark	M1-L	Left	37658.63	38888	38152.62	Rahway
Millburn-Clark	M1-R	Right	37658.63	38888	38152.62	Rahway
Millburn-Clark	M2-L	Left	39069.36	40015	39678.3	Rahway
Millburn-Clark	M2-R	Right	39069.36	40015	39678.3	Rahway
Millburn-Clark	M3-L	Left	51426.3	52244.6	51779.7	Rahway
Millburn-Clark	M3-R	Right	51426.3	52244.6	51779.7	Rahway
Millburn-Clark	M4-L	Left	52244.7	56643.6	54695.58	Rahway
Millburn-Clark	M4-R	Right	52244.7	56643.6	54695.58	Rahway
Millburn-Clark	M5-L	Left	56643.7	59253.5	58354.3	Rahway
Millburn-Clark	M5-R	Right	56643.7	59253.5	58354.3	Rahway
Robinsons Branch	RB1-L	Left	8920.195	10353.94	9748.67	Rahway
Robinsons Branch	RB1-R	Right	8920.195	10353.94	9748.67	Rahway
Robinsons Branch	RB2-L	Left	10533.52	10921.33	10754.22	Rahway
Robinsons Branch	RB2-R	Right	10533.52	10921.33	10754.22	Rahway
Robinsons Branch	RB3-L	Left	10921.4	11739.95	11422.09	Rahway
Robinsons Branch	RB3-R	Right	10921.4	11739.95	11422.09	Rahway
Robinsons Branch	RB4-L	Left	11740	12245.56	12024.56	Rahway
Robinsons Branch	RB4-R	Right	11740	12245.56	12024.56	Rahway
Robinsons Branch	RB5-L	Left	12246.6	12467.23	12310.76	Rahway
Robinsons Branch	RB5-R	Right	12246.6	12467.23	12310.76	Rahway
Robinsons Branch	RB6-L	Left	17696.1	20220	19078.03	Rahway
Robinsons Branch	RB6-R	Right	17696.1	20220	19078.03	Rahway
Robinsons Branch	RB7-L	Left	20220.1	23206.35	21931.45	Rahway
Robinsons Branch	RB7-R	Right	20220.1	23206.35	21931.45	Rahway
Robinsons Branch	RB8-L	Left	23206.4	25160	24170.09	Rahway
Robinsons Branch	RB8-R	Right	23206.4	25160	24170.09	Rahway
Robinsons Branch	RB9-L	Left	25160.1	27333	26431.45	Rahway
Robinsons Branch	RB9-R	Right	25160.1	27333	26431.45	Rahway
Robinsons Branch	RB10-L	Left	27333.1	30132	28937.53	Rahway
Robinsons Branch	RB10-R	Right	27333.1	30132	28937.53	Rahway

4.2.2 Structure Inventory Methodology

A database of residential and nonresidential structures in the study area was compiled to assist in calculating flood damages. The structure inventory data was generated by a survey of the structures in the study area and was mostly obtained through a "windshield survey" of the area in combination with a full elevation survey of ground and main floor elevations for each vulnerable structure. Various data were gathered and physical characteristics assessed during the structure inventory survey, including:

- Structure ID #
- Map Number
- Type of structure
- Use of structure
- Size
- Number of Stories
- Basement Type
- Number of Garages
- Exterior Construction
- Quality of Construction
- Current Condition
- Ground Elevation
- Main Floor Elevation
- Location of Low Openings
- Assigned Reach
- Notes/Description (as required)

Each structure (or distinct use type where multiple usages occur within a single building) was assigned a unique structure identification number following the identification of all structures for inventory using Geographic Information Systems (GIS) mapping. GIS has also been used to determine the footprint size and main floor area for each structure.

4.2.3 Summary of Structure Types and Values

In total 4,298 structures in the study area were identified and subjected to the inventory process for the purposes of damage estimation. The Cranford Upstream study area has 3,365 structures and the Robinson's Branch study area has 933 structures. Tables 5 and 6 present summaries of the distribution of building types in the study area (Cranford Upstream, and Robinson's Branch) and total depreciated structure replacement values at an October 2015 price level by damage categories and municipalities. All depreciated structure replacement values in Tables 5 and 6 are expressed in multiples of $1,000.

Table 5
Summary of Structure Inventory (Cranford Upstream)

Damage Category	**Municipality**					
	Cranford	**Kenilworth**	**Springfield**	**Union**	**Millburn**	**Totals**
Residential #	1,265	146	718	540	374	**3,043**
Residential Value ($,000)	$382,844	$29,799	$170,083	$126,986	$94,921	**$804,633**
Apartment #	0	0	18	10	19	**47**
Apartment Value ($,000)	$0	$0	$28,233	$17,079	$23,794	**$69,107**
Commercial #	48	5	23	15	130	**221**
Commercial Value ($,000)	$24,995	$4,023	$74,461	$146,661	$161,791	**$411,931**
Industrial #	0	1	3	8	0	**12**
Industrial Value ($,000)	$0	$911	$3,418	$18,939	$0	**$23,268**
Municipal #	10	0	9	0	3	**22**
Municipal Value ($,000)	$23,913	$0	$49,789	$0	$1,275	**$74,976**
Institutional #	1	0	1	0	11	**13**

Table 5 Summary of Structure Inventory (Cranford Upstream)						
Institutional Value ($,000)	$5,465	$0	$5,201	$0	$153,001	**$26,731**
Utility #	5	0	1	0	1	**7**
Total #	**1,329**	**152**	**773**	**573**	**538**	**3,365**
Total Value ($,000)	**$437,217**	**$34,733**	**$331,185**	**$309,665**	**$297,846**	**$1,410,646**
% of Total #	**39%**	**5%**	**23%**	**17%**	**16%**	**100%**
% of Total Value	**31%**	**2%**	**23%**	**22%**	**21%**	**100%**

Price level October 2015

Table 6 Summary of Structure Inventory (Robinson's Branch)	
Damage Category	**Municipality**
	Union
Residential #	751
Residential Value ($,000)	$198,989
Apartment	85
Apartment Value ($,000)	$219,829
Commercial #	76
Commercial Value ($,000)	$79,106
Industrial #	4
Industrial Value ($,000)	$19,324
Municipal #	6
Municipal Value ($,000)	$1,383
Institutional #	7
Institutional Value ($,000)	$4,517
Utility	4
Total #	**933**
Total Value ($,000)	**$523,148**

Price Level October 2015

Utility structures have not been assigned dollar structure values since the Passaic River Basin depth-damage functions used for utility structures in this study reference the total foundation area in 1,000s of square feet rather than the depreciated structure value. The values of contents and other assets associated with each structure are discussed in more detail in section 4.2.4.

Table 7 presents a general summary of the proportions of structures found in each damage category type and their average depreciated structure replacement values for the Cranford Upstream study area. Approximately 90% of the structures are of residential (one- or two-family) use, while 7% are commercial properties, and apartment, industrial, municipal, institutional and utility structures together account for less than 3% of the total number of structures in the study area inventory. Residential structures account for 57% of the depreciated structure replacement value, and commercial structures account for 30% of the replacement value in the dataset.

Table 7 Overall Distribution of Damage Category Types (Cranford Upstream)			
Damage Category		**% of Total**	**Average Value**
Residential	*Number*	*90%*	$265,000
	Value	57%	
Apartment	*Number*	*1%*	$1,470,000
	Value	5%	
Commercial	*Number*	*7%*	$1,864,000
	Value	29%	
Industrial	*Number*	*0.40%*	$1,939,000
	Value	2%	
Municipal	*Number*	*1%*	$3,245,000
	Value	5%	
Institutional	*Number*	*0.40%*	$2,056,000
	Value	2%	
Utility	*Number*	*0.20%*	N/A

Price level October 2015

Table 8 presents a general summary of the proportions of structures found in each damage category type and their average depreciated structure replacement values for the Robinson's Branch study area. Approximately 80.5% of the structures are of residential (one- or two-family) use, while 9.1% are apartment properties, 8.1 % commercial properties, and municipal, industrial, institutional and utility structures together account for less than 2.3% of the total number of structures in the study area inventory. Apartment properties account for 42%, residential structures 38. %, commercial properties 15.1% and industrial properties 3.7% of the depreciated structure replacement value of study area dataset.

Table 8 Overall Distribution of Damage Category Types (Robinson's Branch)			
Damage Category		**% of Total**	**Average Value**
Residential	*Number*	80.5%	$265,000
	Value	38.0%	
Apartment	*Number*	9.1%	$2,586,000
	Value	42.0%	
Commercial	*Number*	8.1%	$1,041,000
	Value	15.1%	
Industrial	*Number*	0.4%	$4,831,000
	Value	3.7%	
Municipal	*Number*	0.6%	$231,000
	Value	0.3%	
Institutional	*Number*	0.8%	$645,000
	Value	0.9%	
Utility	*Number*	0.4%	N/A

Price level October 2015

The full inventory of structures used for the calculation of total estimated inundation damages also includes estimates of the numbers and values of motor vehicles likely to be present in the study area and hence exposed to flood damage. The assumptions used to compile these estimates are discussed in detail in Section 4.1.1.4.

4.2.4 Inundation Damage Functions

The computation of annual flood damages in this analysis is based on the application of depth-damage functions to the structures in the study area to compute damage incurred by structures, their contents and other associated features during flood events of different probability of occurrence. The primary source of depth-damage functions for this study were the generic depth-damage functions for residential structures developed for use in U.S. Army Corps of Engineers flood damage reduction studies in 2000 and 2003, and the depth-damage functions for non-residential structures that were developed by the U.S. Army Corps of Engineers specifically for the Passaic River Basin flood damage reduction study during the 1980s.

Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) without basements were applied in accordance with: *Economic Guidance Memorandum (EGM) 01-03, "Generic Depth-Damage Relationships", December 4, 2000.*
Damage functions for single-family residential structures (and two- or multi-family structures with similar physical characteristics) with basements were applied in accordance with: *Economic Guidance*

Memorandum (EGM) 04-01," Generic Depth-Damage Relationships for Residential Structures with Basements", October 10, 2003. Passaic River Basin Damage functions for non-residential structures (plus apartment buildings and large multi-family structures) were applied in accordance with previous experience with similar flood risk reduction projects in northern New Jersey.

Altogether a total of 36 different depth-damage functions were applied to cover the diversity of structure types and usages in the study area; all six generic residential depth-damage functions presented in EGMs 01-03 and 04-01 are represented in the study area, with approximately half of all residential structures assigned the damage function for two-story residences with basements, and approximately three-quarters of all residential structures featuring a subgrade basement. The non-residential and apartment structures in the study area are represented by 30 different Passaic River Basin damage functions, with some such functions being assigned to more than one non-residential usage.

While depreciated structure replacement values were derived using the methodology outlined in Section 4.2.2, the value of contents for each structure was effectively assumed to be equal to 100% of the structure value, in accordance with the appropriate guidance. In addition to damage to structures and associated contents, the Passaic River Basin damage functions for non-residential structures incorporate a third ("other") component for damage to features external to the main structure such as vehicles, storage yards, plant machinery, and landscaping. The value of these features was assumed to be equal to 100% of the structure value, and for most damage functions incorporating this component the percentage of the "other" value realized in damage at each depth is small compared to the corresponding structure or contents damage.

While the generic residential damage functions do not include a component for other damages, the study attempted to capture damages to motor vehicles associated with residences that could be left in the study area during flood events, using USACE guidance found in *Economic Guidance Memorandum 09-04, "Generic Depth-Damage Relationships for Vehicles", June 22, 2009.* To expedite this component of the analysis, a number of simplifying assumptions were made during the estimation of the number and value of vehicles likely to be present in the study area during flood events:

- It was assumed that on average, 1.73 vehicles are associated with each housing unit in the municipalities covered by the study area, based on U.S. Census bureau data.
- The average depreciated value of a vehicle in the study area is $10,000, a value which has been accepted for use in similar studies for USACE elsewhere in the country.
- Sedans were assumed to be the predominant vehicle type in the study area; hence the Sedan depth-damage function in Table 4 of EGM 09-04 was applied to all vehicles in the inventory.
- The total number of housing units was estimated by assuming that each structure covered by one of the generic USACE residential depth-damage functions contained a single unit, and that the number of units in an apartment building can be derived by dividing the building's total square footage by 1,200 (1,000 square feet for the assumed average apartment size plus an additional 200 square feet to account for hallways and other common areas).
- The probability that vehicle owners would move their vehicles to higher ground before a flood was assumed to be 73%. In the absence of any specific information regarding local warning

times in advance of flood events this figure was derived by taking an average of the percentages given in Table 5 of EGM 09-04.

Summaries of the assumed distribution and value of vehicles in the Cranford Upstream and Robinson's Branch study areas are presented in Tables 9 and 10.

Table 9
Distribution of Motor Vehicles in Study Area (Cranford Upstream)

Municipality	Motor Vehicles (Assumed)		
	Number	Value	Modeled Value*
Cranford	2,484	$24,840,000	$6,706,000
Kenilworth	253	$2,530,000	$682,000
Springfield	1,496	$14,960,000	$4,035,000
Union	1,197	$11,970,000	$3,232,000
Millburn	1,008	$10,080,000	$2,718,000
Project Total	**6,438**	**$64,380,000**	**$17,373,000**

*Value adjusted for the probability that vehicles will be removed by owners prior to a flood event.

Table 10
Distribution of Motor Vehicles in Study Area (Robinson's Branch)

Municipality	Motor Vehicles (Assumed)		
	Number	Value	Modeled Value*
Union	4,275	$42,750,000	$11,543,000
Project Total	**4,275**	**$42,750,000**	**$11,543,000**

*Value adjusted for the probability that vehicles will be removed by owners prior to a flood event.

4.2.5 Risk and Uncertainty Parameters

This study has been conducted in accordance with Engineering Manual EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies (USACE, August 1, 1996), which requires that primary elements of the damage estimation computations are explicitly subjected to probabilistic analyses. Estimates of annual flood damage were computed for this study using version 1.4 of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA), which applies Monte Carlo simulation techniques to calculate expected damage values while explicitly accounting for uncertainty in the input data.

Uncertainty was incorporated into the following components of the flood damage calculations:

- Discharge-frequency functions
- Stage-discharge functions
- Stage-frequency functions
- Structure first floor elevation
- Structure depreciated replacement value
- Content/other value-structure value ratios
- Depth-damage functions

Uncertainty associated with the discharge-frequency relationship in reaches subject to steady state hydraulic modeling (i.e. all reaches in the Millburn stream) was applied in HEC-FDA using order statistics and equivalent record lengths. For this analysis an equivalent record length of 60 years was used to generate uncertainty bands for all reaches in the Millburn stream for all conditions.

Uncertainty was applied to stage-discharge functions in reaches subject to steady state hydraulic modeling applying a normal probability distribution with a standard deviation of 0.5 feet to the stages for all conditions.

Uncertainty associated with the stage-frequency relationship in reaches subject to unsteady state hydraulic modeling (i.e. all reaches in the Cranford-Springfield and Lower streams) was applied using order statistics and equivalent record lengths. For this analysis an equivalent record length of 60 years was used for all reaches upstream of a river gage at Route 22 in Springfield (i.e. upstream of station 21641 on the Cranford-Springfield stream) and 80 years for all reaches downstream of the gage.

Uncertainty associated with the main floor elevation of single-family (and similar two-family) residential structures was applied using a normal distribution with a standard deviation of 0.6 feet, in accordance with guidance in Table 6-5 of EM 1110-2-1619 for inventories compiled by visual survey and topographic mapping with two-foot contour intervals. The uncertainty associated with the main floor elevation of non-residential, larger residential and apartment structures that were assigned Passaic River Basin damage functions was applied using a normal distribution with a standard deviation of 1.0 feet, in accordance with previous practice when using this set of damage functions.

The depreciated structure replacement value was subjected to uncertainty via the application of a normal probability distribution with a coefficient of variation of 10% for all structures, in accordance with previously accepted practice for similar USACE flood damage reduction studies. For non-residential and apartment structures the ratios between content value and structure value, and between other value and structure value, was subjected to uncertainty via the application of normal distributions with a coefficient of variation of 25% and 10% respectively, also in accordance with previously accepted practice for similar USACE flood damage reduction studies. These ratios are not applicable to the generic damage functions for residential structures.

Depth damage functions were also subjected to uncertainty in accordance with the guidance referenced in Section 4.2.4: Residential damage functions for both structure and content damage were subjected to uncertainty using normal distributions (standard deviation varying with depth), while the Passaic River Basin functions for non-residential and apartment structures do not feature specifically-defined uncertainty relationships associated with the depth-damage curves for structure, content, and other damage.

4.2.6 Without-Project Damages Summary

Using HEC-FDA, Average Annual Damages (AAD) were calculated for the without-project base year (2023) and the future condition, and Equivalent Annual Damages (EAD) were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and federal plan formulation discount rate of 3.125%. The total equivalent annual damage resulting in these calculations is almost $9.8 million for the Cranford Upstream study area and $2.7 million for the Robinson's Branch study area. A summary of the total equivalent annual damages for the without-project condition by municipality is presented in Table 11 for Cranford Upstream, and Table 12 for Robinson's Branch.

Table 11
Summary of Without-Project Equivalent Annual Damage (Cranford Upstream)

Municipality	Total Damage	% of Total
Cranford	$3,061,550	31%
Kenilworth	$161,040	2%
Springfield	$1,241,360	13%
Union	$1,606,000	16%
Millburn	$3,703,680	38%
Total	$9,773,630	100%

Price level: October 2015, 3.125% Discount rate.

Table 12
Summary of Without-Project Equivalent Annual Damage (Robinson's Branch)

Municipality	Total Damage
Rahway	$2,695,830

Price level: October 2015, 3.125% Discount rate.

Table 13 presents a summary of the numbers of structures experiencing damage at selected annual chance exceedance events across the Cranford Upstream study area, broken down by damage category. Note that Table 13 was compiled without the application of risk and uncertainty to water surface elevations or structure elevations in the HEC-FDA model. Table 14 presents the summary of structures for the Robinson's Branch study area.

Table 13 Summary of Damaged Structures by Flood Event (Cranford Upstream)							
Damage Category	**Annual Chance Exceedance Event**						
	50% (2-yr)	**20% (5-yr)**	**10% (10-yr)**	**4% (25-yr)**	**2% (50-yr)**	**1% (100-yr)**	**>1% (>100-yr)**
Residential	20	35	107	410	803	1,270	3,043
Apartment	2	3	3	7	11	12	47
Commercial	2	6	15	42	63	87	221
Industrial	0	0	0	5	6	7	12
Institutional	0	0	0	0	1	4	13
Municipal	0	1	1	3	10	10	22
Utility	0	1	1	4	5	5	7
Total	24	46	127	471	899	1,395	3,365

Table 14 Summary of Damaged Structures by Flood Event (Robinson's Branch)							
Damage Category	**Annual Chance Exceedance Event**						
	50% (2-yr)	**20% (5-yr)**	**10% (10-yr)**	**4% (25-yr)**	**2% (50-yr)**	**1% (100-yr)**	**>1% (>100-yr)**
Residential	4	8	18	70	130	220	751
Apartment	0	0	3	5	6	13	85
Commercial	8	10	12	16	21	23	75
Industrial	0	0	1	1	2	2	5
Institutional	0	0	0	0	1	1	7
Municipal	0	0	0	0	0	1	6
Utility	1	1	1	1	2	2	4
Total	13	19	35	93	162	262	933

4.2.7 Damage Verification

Efforts to verify the computed damages consisted of two principal activities:

- Detailed review of the structure database and additional research to verify the physical attributes of structures exhibiting very high damages in the initial model runs.
- A comparison of event damages computed by HEC-FDA with National Flood Insurance Program (NFIP) payouts for recent flood events with established return periods.

The additional research was undertaken after the initial computation of damages and was focused on those structures exhibiting damage in the model at the 50% annual chance exceedance ("two-year") event, and/or those exhibiting annual average damages in excess of $20,000. These structures were targeted since significant flooding at that frequency has not been locally reported, and it was assumed that under most circumstances, a structure regularly experiencing that magnitude of flooding would have been rendered unusable/uninhabitable. The targeted structures were researched using publicly available resources including Google Earth, Google Street View, and USGS topographic data. For some structures in the inventory, adjustments were subsequently made to key attributes such as station, ground and main floor elevations, foundation type, and damage function in order to align the damages more closely with local reports and expectations.

Without-project structure damages computed using HEC-FDA were compared with reported damages (in the form of claims paid by the National Flood Insurance Program and other public sources) for two flood events in the study area which have known or accepted return periods; the Nor'easter of April 2007, which was considered to have been a 3.7% annual chance exceedance (or "27-year") event at this location, and Tropical Storm Irene in August 2011, which has been estimated to be close to a 0.9% annual chance exceedance (or "110-year") event. NFIP claims data was available for the April 2007 event for the municipalities of Cranford and Kenilworth, and the comparison of this data with results extracted from the closest return period in the HEC-FDA model is presented in Table 15.

Table 15
Comparison of Modeled versus Recorded NFIP Damages: April 2007 Nor'easter

	Cranford	**Kenilworth**
Policies in force in 2007	634	169
Paid Claims 2007	303	7
Paid Building claims	302	7
Building Damage Paid 2007	$5,283,000	$25,000
Average Building Damage Paid	$17,493	$3,571
HEC-FDA Structures damaged 25-Year	230	5
HEC-FDA 25-Year Structure Damage	$10,235,000	$183,000
Average HEC-FDA Structure Damage	$44,500	$36,600

Limited NFIP claims data was also available for Tropical Storm Irene for Cranford and Kenilworth, and the comparison of this data with results extracted from the closest return period in the HEC-FDA model is presented in Table 16.

Table 16 Comparison of Modeled versus Recorded NFIP Damages: Tropical Storm Irene		
	Cranford	**Kenilworth**
Policies in force in 2010	681	168
Policies in Force in 2013	888	180
Paid Claims for Irene (as of 9/30/2011)	23	8
Paid Building claims for Irene (as of 9/30/2011)	20	8
Building Damage Paid for Irene (as of 9/30/2011)	$844,000	$138,000
Average Building Damage Paid (as of 9/30/2011)	$42,192	$17,248
Open Claims for Irene (as of 9/30/2011)	438	76
Extrapolated Building Damage[1]	$19,324,000	$1,449,000
HEC-FDA Structures damaged 100-Year	729	81
HEC-FDA 100-Year Structure Damage	$32,060,000	$2,538,000
Average HEC-FDA Structure Damage	$43,978	$29,111

1. Assuming the remaining open claims each resulted in payouts close to the average paid amount.

In addition to the limited amount of NFIP data available for Tropical Storm Irene, further information was gathered from a statement issued by the Rahway River Watershed Mayors' Council. This statement reports that Irene impacted 1,600 structures in Cranford, with 300 structures receiving damage to the main floor (compared to 203 Cranford structures experiencing water above the main floor in the 100-year HEC-FDA event), and $16.5 million in damages to residences, plus $4 million in damages to two schools. The resulting total of approximately $20 million in damages before damage to other non-residential structures is accounted for compares reasonably well with the total HEC-FDA damage of $32 million for Cranford.

The Mayors' Council statement also indicated that during Irene damages totaling $15 million were incurred to 412 structures in Union Township (compared to 143 structures experiencing $26 million damages in the HEC-FDA model), and that damages totaling $8 million were experienced by more than 80 homes in Springfield Township during the same event. This compares to 222 structures experiencing $17 million damages in the HEC-FDA model for the 100-year event.

For Tropical Storm Irene, it is noticeable that in Cranford only about 4% of the recorded claims had been paid out at the time this data became available, and that the average paid for structure damage was within 5% of the average damage experienced by affected structures in HEC-FDA. Assuming that all the remaining claims were settled at amounts close to the average already paid out, the total building damage from Irene would be in the region of $19 million, compared to $32 million computed by the HEC-FDA model for an event of similar frequency.

Differences between flood damages modeled in HEC-FDA and NFIP losses are not uncommon in studies of this nature, and may be accounted for by several factors, including the following:

- Since the number of policies in force was only available for years either side of the year in which Tropical Storm Irene occurred, it is not immediately possible to determine how many were in force at the time of the event, but the jump in the number from 2010 to 2013 suggests that a significant number of vulnerable structures were uninsured or had allowed their policies to lapse prior to Irene.

- The geographical location of structures with current NFIP policies was not readily available; it could not be confirmed that all the policies in force were associated with structures vulnerable to flooding from the Rahway River mainstem, and not from other flooding sources such as tributaries and areas with localized drainage issues.
- Some property owners (particularly non-residential owners) may have experienced damage exceeding the limits of their coverage.
- The comparison does not take into account price level escalation from 2011 to 2013 or policy holders' deductibles and out of pocket expenses.

5.0 Evaluation of Alternatives

5.1 Overview

The economic analysis divided the study into two areas, Cranford Upstream covering municipalities of Cranford, Kenilworth, Springfield, Union, and Milburn, and Robinson's Branch covering the City of Rahway.

5.2 Cranford Upstream Alternative 1

5.2.1 Description

Major channel modification at the Rahway River at Cranford Township, and modification to Lenape Park Detention Basin. This alternative is to manage flood risk from a 1% chance of annual exceedance flood (100-yr event) in Cranford Township.

The Lenape dam modifications will include:

- Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
- Widening the spillway by 100 ft.
- Widening the orifice to 40 ft. and lowering by 0.5 ft.
- Modifying 10,000 ft. dam embankments by raising 6 ft.
- Widening the auxiliary spillway to 400 ft.
- Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

This plan also includes approximately 15,500 ft. of channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd., just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The downstream slope is approximately 2.6 ft. /mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of a natural channel bed or riprap material and a 60 ft. bottom width. The side slopes ranges from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced.

5.2.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 1 is presented in Table 17.

Table 17 Cranford Upstream Alternative 1 Costs	
First Cost	$91,123,800
Interest during Construction	$3,475,279
Total Investment Cost	$94,599,079

Annual investment cost	$3,764,377
O&M	$331,900
Annual Cost	$4,096,300

Price Level: FY2014, 3.125% Discount rate.

5.2.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Alternative 1 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 1 is presented in Table 18. A summary of benefits arising from the implementation of Cranford Upstream Alternative 1 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0. It is evident that while Cranford Upstream Alternative 1 generates more than $2.2 million in flood damage reduction benefits, a small amount of induced flood damage would be produced in Union. While this damage is negligible when compared to the overall project benefits, implementation of this measure would require some specific additional mitigation measures to prevent this damage and hence comply with current plan formulation policy.

Table 18
Summary of Damages and Benefits for Cranford Upstream Alternative 1

Municipality	Without Project	With Alternative 1	Damage Reduction Benefits
Cranford	$3,061,550	$993,880	$2,067,670
Kenilworth	$161,040	$83,000	$78,040
Springfield	$1,241,360	$1,104,340	$137,020
Union	$1,606,000	$1,614,860	-$8,860
Millburn	$3,703,680	$3,703,150	$530
Total	**$9,773,630**	**$7,499,230**	**$2,274,400**

Price Level: FY2016, 3.125% Discount rate.

5.3 Cranford Upstream Alternative 2

5.3.1 Description

Limited channel modification at the Rahway River at Cranford Township, and modification to the Nomahegan levees and Lenape Park Detention Basin. This alternative is to manage flood risk from a 1% chance of annual exceedance flood (100-yr event) in Cranford Township. Modifications to Lenape Dam are similar to modifications included in alternative 1

The Lenape dam modifications will include:

- Replacing the existing Lenape Dam spillway structure and raising by 6 ft.

- Widening the spillway by 100 ft.
- Widening the orifice to 40 ft. and lowering by 0.5 ft.
- Modifying 10,000 ft. dam embankments by raising 6 ft.
- Widening the auxiliary spillway to 400 ft.
- Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

The levee system to be modified is located in the Nomahegan Park area. The proposed levees will be approximately 6 ft. higher than the existing levees. A fifteen foot wide vegetation free zone will be added to each side of the reconstructed levees. Because of environmental considerations and the negative impact of a channel through Nomahegan Park, this plan includes reducing channel work to approximately 9,700 ft. throughout the extent of the Rahway River in Cranford Township. The channel work extends from about 200 ft. upstream of Springfield Ave. Bridge to a point approximately 1,000 ft. downstream of the Lincoln Ave. Bridge. The downstream slope is approximately 2.7 ft. /mile with a maximum deepening of about 4 ft. near Hansel Dam. The trapezoidal channel will consist of a natural channel bed or riprap material and a 70 ft. bottom width. The side slopes ranges from one vertical on two horizontal (1 on 2), to one vertical on two and a half horizontal (1 on 2.5). There will be approximately 3,400 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced.

5.3.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 2 is presented in Table 19.

Table 19 Cranford Upstream Alternative 2 Costs	
First Cost	$90,816,400
Interest during Construction	$3,463,556
Total Investment Cost	$94,279,956
Annual investment cost	$3,751,678
O&M	$322,500
Annual Cost	$4,074,200

Price Level: FY2014, 3.125% Discount rate.

5.3.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 2 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 2 is presented in Table 20. A summary of benefits arising from the implementation of Cranford Upstream Alternative 2 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0. It is evident that while

Cranford Upstream Alternative 2 generates more than $2.3 million in flood damage reduction benefits, a small amount of induced flood damage would be produced in Union Township. While this damage is negligible when compared to the overall project benefits, implementation of this measure would require some specific additional mitigation measures to prevent this damage and hence comply with current plan formulation policy.

Table 20
Summary of Damages and Benefits for Cranford Upstream Alternative 2

Municipality	Without Project	With Alternative 2	Damage Reduction Benefits
Cranford	$3,061,550	$975,030	$2,086,520
Kenilworth	$161,040	$80,270	$80,770
Springfield	$1,241,360	$1,038,880	$202,480
Union	$1,606,000	$1,626,560	-$20,560
Millburn	$3,703,680	$3,703,150	$530
Total	**$9,773,630**	**$7,423,890**	**$2,349,740**

Price Level: FY2016, 3.125% Discount rate.

5.4 Cranford Upstream Alternative 3

5.4.1 Description

Dredging Orange Reservoir to increase storage capacity and major channel modification of the Rahway River in Cranford Township. This alternative is to manage flood risk from between a 2% to a 1% chance of annual exceedance flood (50yr to a100-yr event) in Cranford Township.

This plan includes approximately 15,500 ft. of channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd, just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The downstream slope is approximately 2.6 ft. /mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of natural channel bed or riprap material and a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative 1.

In addition, this plan includes the use and operation of Orange Reservoir for flood water storage. This included the dredging of approximately 375,000 cubic yards of sediment in the reservoir, to return it to its original maximum capacity, and installing additional outlet pipes in the dam structure. The area to be dredged is approximately 65 acres. The additional pipes will help lower the reservoir prior to a storm to maximize the effective use of the new storage capacity of the reservoir.

5.4.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 3 is presented in Table 21.

Table 21 Cranford Upstream Alternative 3 Costs	
First Cost	$230,303,600
Interest during Construction	$14,459,429
Total Investment Cost	$244,763,029
Annual investment cost	$9,739,844
O&M	$970,200
Annual Cost	$10,710,000

Price Level: FY2014, 3.125% Discount rate.

5.4.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 3 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 3 is presented in Table 22. A summary of benefits arising from the implementation of Cranford Upstream Alternative 3 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 22
Summary of Damages and Benefits for Cranford Upstream Alternative 3

Municipality	Without Project	With Alternative 3	Damage Reduction Benefits
Cranford	$3,061,550	$961,480	$2,100,070
Kenilworth	$161,040	$72,140	$88,900
Springfield	$1,241,360	$875,860	$365,500
Union	$1,606,000	$1,108,420	$497,580
Millburn	$3,703,680	$1,919,220	$1,784,460
Total	**$9,773,630**	**$4,937,120**	**$4,836,510**

Price Level: FY2016, 3.125% Discount rate.

5.5 Cranford Upstream Alternative 4

5.5.1 Description

Orange Reservoir Dam modifications and channel modification in Cranford Township. This alternative is to manage flood risk from between a 2% to a 1% chance of annual exceedance flood (50-yr to a 100-yr event) in Cranford Township.

The plan requires minimum modification to Orange Dam that includes two additional 36 in. diameter outlet pipes at the dam and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum depth of about 30 ft. to a depth of about 15 feet. This plan requires little to no dredging in the reservoir.

This plan also includes approximately 15,500 ft. channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd, just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The downstream slope is approximately 2.6 ft. /mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of natural channel bed or riprap material and a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of replaced retaining walls. Also, the N. Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative 1.

5.5.2 Cost Estimate (USACE-NYD)

A summary of the costs for Cranford Upstream Alternative 4 is presented in Table 23.

Table 23 Cranford Upstream Alternative 4 Costs	
First Cost	$134,723,100
Interest during Construction	$5,138,069
Total Investment Cost	$139,861,169
Annual investment cost	$5,565,489
O&M	$485,100
Annual Cost	$6,050,600

Price Level: FY2014, 3.125% Discount rate.

5.5.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 4 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 4 is presented in Table 24. A summary of benefits arising from the implementation of Cranford Upstream Alternative 4 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 24
Summary of Damages and Benefits for Cranford Upstream Alternative 4

Municipality	Without Project	With Alternative 4	Damage Reduction Benefits
Cranford	$3,061,550	$1,025,060	$2,036,490
Kenilworth	$161,040	$74,810	$86,230
Springfield	$1,241,360	$951,470	$289,890
Union	$1,606,000	$1,217,090	$388,910
Millburn	$3,703,680	$2,022,470	$1,681,210
Total	**$9,773,630**	**$5,290,900**	**$4,482,730**

Price Level: FY2016, 3.125% Discount rate.

5.6 Cranford Upstream Alternative 4a

5.6.1 Description

Replacement in-kind of Orange Dam with outlet modifications and limited channel modification in Cranford Township. This alternative is to manage flood risk from between a 2% to 4% chance of annual exceedance flood (25-yr event ~ 50-yr event) in Cranford Township. The plan requires two additional 36 in. diameter outlet pipes at the dam and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum reservoir depth of about 30 ft. to a depth of about 15 feet. A recent bathymetric survey determined that the reservoir has 200 acre-ft. more storage capacity at the spillway elevation (than was assumed earlier in this study. Thus, the recommended final drawdown elevation will be adjusted based on acceptable reservoir re-fill times, environmental consideration and the desired level of risk management. This plan requires little to no dredging in the reservoir.

This plan also requires approximately 8,930 ft. of channel modification. The proposed channel modification starts in the vicinity of the footbridge by Nomahegan Park and ends approximately 650 ft. downstream of South Ave. E. The slope is approximately 2.6 ft. /mile with a maximum deepening of about 1.9 ft. in the vicinity Hansel Dam. The new trapezoidal channel will consist of a natural channel bed with a 35 to 45 ft. bottom width and side slopes of one vertical on two and a half horizontal (1:2.5). There is some riprap material in a small segment of the river near the Eastman Ave. Bridge at McConnell Park. No dam or bridge removals in the vicinity of Cranford were included in this alternative.

5.6.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 4a is presented in Table 25.

Table 25 Cranford Upstream Alternative 4a Costs	
First Cost	$69,570,000
Interest during Construction	$3,790,418
Total Investment Cost	$73,360,418
Annual investment cost	$2,919,228
O&M	$258,000
Annual Cost	$3,177,200

Price Level: FY2016, 3.125% Discount rate.

5.6.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 4a in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative Cranford 4a is presented in Table 26. A summary of benefits arising from the implementation of Cranford Upstream Alternative 4a and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 26
Summary of Damages and Benefits for Cranford Upstream Alternative 4a

Municipality	Without Project	With Alternative 4a	Damage Reduction Benefits
Cranford	$3,061,550	$1,958,520	$1,103,030
Kenilworth	$161,040	$101,200	$59,840
Springfield	$1,241,360	$879,500	$361,860
Union	$1,606,000	$1,108,590	$497,410
Millburn	$3,703,680	$2,022,470	$1,681,210
Total	**$9,773,630**	**$6,070,280**	**$3,703,350**

Price Level: FY2016, 3.125% Discount rate.

5.7 Cranford Upstream Alternative 5

5.7.1 Description

The plan consist of channel modification at the Rahway River at Cranford Township and the construction of a South Mountain Dry Detention Basin with Brookside Drive relocated to provide uninterrupted traffic access. The alternative is to manage flood risk from a 1% chance of annual exceedance (100-yr event) in Cranford Township.

This plan includes approximately 15,500 ft. channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd., just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of channel work is expected in Nomahegan Park. The downstream slope is approximately 2.6 ft. /mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The trapezoidal channel will consist of a combination of natural bed channel or riprap material, a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative 1.

In addition, this plan includes a new dry detention structure in South Mountain Reservation just upstream of Campbell's Pond. The structure will be approximately 810 ft. long by 75 ft. high. The area flooded during a storm event of 0.2% chance of exceedance (500-yr event) is approximately 85 acres and the dam structure will have a footprint of approximately 6.6 acres. The dry detention structure will provide approximately 2,500 acre-ft. of flood water storage to the downstream communities. This plan also requires the relocation of approximately 3,000 ft. Brookside Drive and a steel truss maintenance bridge across the spillway of the dam.

5.7.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 5 is presented in Table 27.

Table 27 Cranford Upstream Alternative 5 Costs	
First Cost	$174,019,300
Interest during Construction	$13,859,878
Total Investment Cost	$187,879,178
Annual investment cost	$7,476,268
O&M	$571,300
Annual Cost	$8,047,600

Price Level: FY2014, 3.125% Discount rate.

5.7.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 5 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 5 is presented in Table 28. A summary of benefits arising from the implementation of Cranford Upstream Alternative 5 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 28 Summary of Damages and Benefits for Alternative 5			
Municipality	**Without Project**	**With Alternative 5**	**Damage Reduction Benefits**
Cranford	$3,061,550	$678,430	$2,383,120
Kenilworth	$161,040	$35,060	$125,980
Springfield	$1,241,360	$468,340	$773,020
Union	$1,606,000	$707,640	$898,360
Millburn	$3,703,680	$1,165,240	$2,538,440
Total	**$9,773,630**	**$3,054,710**	**$6,718,920**

Price Level: FY2016, 3.125% Discount rate.

5.8 Cranford Upstream Alternative 6

5.8.1 Description

The plan consist of a new dry detention structure in South Mountain Reservation (standalone) with Brookside Drive relocated to provide uninterrupted traffic access. The structure will be approximately 810 ft. long by 75 ft. high. The area flooded during a storm event of 0.2% chance of exceedance (500-yr event) is approximately 85 acres and the dam structure will have a footprint of approximately 6.6 acres. The dry detention structure will provide approximately 2,500 acre-ft. of flood water storage to the downstream communities. This plan also requires the relocation of approximately 3,000 ft. of Brookside Drive and a steel truss maintenance bridge across the spillway of the dam.

5.8.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 6 is presented in Table 29.

Table 29 Cranford Upstream Alternative 6	
First Cost	$118,576,200
Interest during Construction	$5,486,355
Total Investment Cost	$124,062,555
Annual investment cost	$4,936,816
O&M	$349,100
Annual Cost	$5,285,900

Price Level: FY2016, 3.125% Discount rate.

5.8.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 6 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 6 is presented in Table 30. A summary of benefits arising from the implementation of Cranford Upstream Alternative 6 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 30
Summary of Damages and Benefits for Cranford Upstream Alternative 6a

Municipality	Without Project	With Alternative 6a	Damage Reduction Benefits
Cranford	$3,061,550	$1,745,030	$1,316,520
Kenilworth	$161,040	$80,810	$80,230
Springfield	$1,241,360	$473,360	$768,000
Union	$1,606,000	$708,270	$897,730
Millburn	$3,703,680	$1,165,130	$2,538,550
Total	**$9,773,630**	**$4,172,600**	**$5,601,030**

Price Level: FY2016, 3.125% Discount rate.

5.9 **Cranford Alternative 7a: (Nonstructural 10-Year)**

5.9.1 Description

A nonstructural alternative is one in which the physical mechanism and extent of flooding is largely unchanged (no riverine structures are constructed or modified to substantially constrain, impede or redirect floodwater) but the existing buildings within the floodplain are instead adapted or the regulatory framework that governs new development is modified to reduce the damage incurred during flood events. For this study, only nonstructural measures which directly affect existing buildings have been incorporated into the analysis.

Nonstructural treatments were applied to structures in the Cranford Township portion of the study area using a spreadsheet matrix which considered physical characteristics including building configuration, usage, footprint size, foundation type, and existing main floor elevation in order to select and cost the most appropriate/feasible treatment for each structure. The nonstructural analysis considered 10 different treatment measures for application, which can be described under the following broad categories:

- Elevation: the structure is physically raised so that the main floor of the structure is at or above the specified design protection level.

- Dry floodproof: all openings are sealed or fitted with moveable watertight barriers and the exterior walls are treated to make them waterproof to the design protection level.
- Wet floodproof: wet floodproofing is generally applied to structures with a main floor elevation already above the design protection level but which still incur significant damages due to the presence of basements and vulnerable utilities. Treatments include the vacating or filling of basements, removal of utilities, and the provision of equivalent facilities above the design protection level. Wet floodproofing also includes a number of minor treatments such as the raising of exterior air conditioning units and the provision of louvers in crawlspace walls to allow the equalization of hydrostatic pressure.
- Ringwall: the structure (and in some cases, groups of closely adjacent structures) is encircled by a floodwall constructed to the design protection elevation.
- Acquisition: removal of the structure from the floodplain through demolition. Lands are then preserved for open space uses (also known as "buyout").

The design protection level for this analysis was based on the water surface elevation with a 1% annual chance of being equaled or exceeded (the "100-year flood") plus one foot, and the analyzed Cranford Alternative 7a included all structures considered to be in the 10-year floodplain in Cranford Township. While nonstructural measures reduce the risk of damage to individual structures and their contents, they are assumed not to reduce damages to exterior items such as vehicles and landscaping. It should also be noted that except for ringwalls and dry floodproof measures, some residual structure damage can still be incurred below the design level of protection following the implementation of nonstructural measures. The structures identified for nonstructural treatments are summarized in Table 31.

Table 31 Nonstructural Measures Cranford Upstream

Nonstructural Flood Proofing Measure	10% (10-yr) Annual Exceedance			1% (100-yr) Annual Exceedance		
	Residential	Non-Residential	Sub Total	Residential	Non-Residential	Sub Total
Dry Flood proofing	0	0	0	7	4	11
Wet Flood proofing	1	0	1	326	0	326
Barriers	1	0	1	32	5	37
Raise	62	0	62	310	1	311
Buyout	2	0	2	36	5	41
Total of Structures	66	0	**66**	711	15	**726**

5.9.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 7a is presented in Table 32.

Table 32 Cranford Upstream Alternative 7a Costs

First Cost	$19,447,800
Interest during Construction	$593,700
Total Investment Cost	$20,041,500

Annual investment cost	$797,511
O&M	$137,803
Annual Cost	$935,300

Price Level: FY2016, 3.125% Discount rate.

5.9.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Alternative 7a in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Alternative 7a is presented in Table 33. A summary of benefits arising from the implementation of Cranford Alternative 7a and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 33
Summary of Damages and Benefits for Cranford Upstream Alternative 7a

Municipality	Without Project	With Alternative 7a	Damage Reduction Benefits
Cranford	$3,061,550	$2,071,260	$990,290
Kenilworth	$161,040	$161,040	$0
Springfield	$1,241,360	$1,241,360	$0
Union	$1,606,000	$1,606,000	$0
Millburn	$3,703,680	$3,703,680	$0
Total	**$9,773,630**	**$8,783,340**	**$990,290**

Price Level: FY2016, 3.125% Discount rate.

5.10 Cranford Upstream Alternative 7b (Nonstructural 100-Year)

5.10.1 Description

While the methodology and assumptions used to assign nonstructural treatments to individual structures under Cranford Upstream Alternative 7b were identical to those for Cranford Upstream Alternative 7a, in this alternative the analysis included all structures considered to be in the 100-year floodplain in Cranford Township. The structures identified for nonstructural treatments are summarized in Table 31.

5.10.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 7b is presented in Table 34.

Table 34 Cranford Upstream Alternative 7b Costs	
First Cost	$186,935,700
Interest during Construction	$5,706,700
Total Investment Cost	$192,642,400
Annual investment cost	$7,665,810
O&M	$136,900
Annual Cost	$7,802,700

Price Level: FY2014, 3.125% Discount rate.

5.10.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 7b in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 7b is presented in Table 35. A summary of benefits arising from the implementation of Cranford Upstream Alternative 7b and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 35
Summary of Damages and Benefits for Cranford Upstream Alternative 7b

Municipality	Without Project	With Alternative 7b	Damage Reduction Benefits
Cranford	$3,061,550	$783,710	$2,277,840
Kenilworth	$161,040	$161,040	$0
Springfield	$1,241,360	$1,241,360	$0
Union	$1,606,000	$1,606,000	$0
Millburn	$3,703,680	$3,703,680	$0
Total	**$9,773,630**	**$7,495,790**	**$2,277,840**

Price Level: FY2016, 3.125% Discount rate.

5.11 Cranford Upstream Alternative 8

5.11.1 Description

The alternative consists of the replacement of Lenape and Orange Dams. The Lenape dam replacement will include:

- Replacing the existing Lenape Dam spillway structure and raising it by 6 ft.

- Widening the spillway by 100 ft.
- Widening the orifice to 40 ft. and lowering by 0.5 ft.
- Removing approximately 10,000 ft. existing earthen dam embankments and replacing with a 6 ft. higher embankment. Also widening the top of the embankments to 25 ft.
- Providing a little more than a 100 foot wide vegetation free zone centered around the dam embankments.
- Widening the auxiliary spillway to 400 ft.
- Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

The plan requires the replacement in-kind of Orange Dam and includes two additional 36 in. diameter outlet pipes and operation two days prior to a storm event. The recommended final drawdown elevation will be adjusted based on acceptable reservoir re-fill times, environmental consideration and the desired level of risk management. This plan requires little to no dredging in the reservoir.

5.11.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 8 is presented in Table 36.

Table 36 Cranford Upstream Alternative 8 Costs	
First Cost	$113,212,500
Interest during Construction	$4,317,698
Total Investment Cost	$117,530,198
Annual investment cost	$4,676,874
O&M	$384,400
Annual Cost	$5,061,300

Price Level: FY2016, 3.125% Discount rate

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5.11.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 8 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 8 is presented in Table 37. A summary of benefits arising from the implementation of Cranford Upstream Alternative 8 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 37 Summary of Damages and Benefits for Cranford Upstream Alternative 8			
Municipality	**Without Project**	**With Alternative 8**	**Damage Reduction Benefits**
Cranford	$3,061,550	$1,693,320	$1,368,230
Kenilworth	$161,040	$85,580	$75,460
Springfield	$1,241,360	$812,050	$429,310
Union	$1,606,000	$1,142,090	$463,910
Millburn	$3,703,680	$2,022,530	$1,681,150
Total	**$9,773,630**	**$5,755,570**	**$4,018,060**

Price Level: FY2016, 3.125% Discount rate.

5.12 Cranford Upstream Alternative 9

5.12.1 Description

The alternative consist on the replacement of Lenape and Orange Dams, and limited channel modification in Cranford. The Lenape dam replacement includes:

- Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
- Widening the spillway by 100 ft.
- Widening the orifice to 40 ft. and lowering by 0.5 ft.
- Removing approximately 10,000 ft. existing earthen dam embankments and replacing with a 6 ft. higher embankment. Also widening the top of the embankments to 25 ft.
- Providing a little more than a 100 foot wide vegetation free zone centered around the dam embankments.
- Widening the auxiliary spillway to 400 ft.
- Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

There will be approximately 8,930 ft. of channel work throughout the extent of the Rahway River in Cranford Township, from the footbridge at Nomahegan Park to a point approximately 650ft. downstream of the South Ave. Bridge. The general slope of the channel cut will be approximately 2.6 ft. /mile with a maximum deepening of about 1.9 ft. in the vicinity of Hansel Dam. The new trapezoidal channel will consist of a natural bed channel with a 35 to 45 ft. bottom width and side slopes of one vertical on two and a half horizontal (1:2.5). There is some riprap material in a small segment of the river near the Eastman Ave. Bridge at McConnell Park. No dam or bridge removal in Cranford is expected in this alternative.

The plan requires the replacement in-kind of Orange Dam and includes two additional 36 in. diameter outlet pipes and operation two days prior to a storm event. The recommended final drawdown elevation will be adjusted based on acceptable reservoir re-fill times, environmental consideration and the desired level of risk management. This plan requires little to no dredging in the reservoir.

5.12.2 Cost Estimate

A summary of the costs for Cranford Upstream Alternative 8 is presented in Table 38.

Table 38 Cranford Upstream Alternative 9 Costs	
First Cost	$128,949,300
Interest during Construction	$4,917,868
Total Investment Cost	$133,867,168
Annual investment cost	$5,326,970
O&M	$414,600
Annual Cost	$5,741,600

Price Level: FY2016, 3.125% Discount rate.

5.12.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Cranford Upstream Alternative 9 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Cranford Upstream Alternative 9 is presented in Table 39. A summary of benefits arising from the implementation of Cranford Upstream Alternative 9 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 39
Summary of Damages and Benefits for Upstream Cranford Alternative 9

Municipality	**Without Project**	**With Alternative 9**	**Damage Reduction Benefits**
Cranford	$3,061,550	$1,220,410	$1,841,140
Kenilworth	$161,040	$79,670	$81,370
Springfield	$1,241,360	$1,052,060	$189,300
Union	$1,606,000	$1,134,120	$471,880
Millburn	$3,703,680	$2,022,470	$1,681,210
Total	**$9,773,630**	**$5,508,730**	**$4,264,900**

Price Level: FY2016, 3.125% Discount rate.

5.13 Robinson's Branch Alternative 1

5.13.1 Description

This alternative is a reevaluation of the 1985 GRR Plan which consists of levees, floodwalls and channel modification. This plan includes approximately 8,300 ft. of channel work throughout the Robinson's Branch and Rahway River. In Robinson's Branch, the channel starts about 600 ft. downstream of Maple Ave. Bridge and ends in the confluence with Rahway River. In the Rahway River, the channel starts about 75 ft. upstream of W Grand Ave. Bridge and ends approximately 550 ft. downstream of the Monroe Ave. Bridge. All channel cuts generally consist of a 35 ft. wide trapezoidal channel with natural bed and one vertical on two and a half horizontal (1:2.5) side slopes. There are also a few sections with rectangular cuts of 60 ft. wide and a 20 ft. wide pilot channels in Robinson's Branch. Riprap protection is proposed at the upstream end of the channel modification in Robinson's Branch and between the Elizabeth Ave. and Rail Road Bridges in the Rahway River.

There are also approximately 1,350 ft. of levees and 4,000 ft. of floodwalls included in this plan. These levees and floodwalls were divided into three systems. The Robinson's Branch right bank, System 1 extends from high ground near W Milton Ave. down to St. Georges Ave. (approx. 1,300 ft. of levee/floodwall) and System 2 extends a short distance from Hamilton St. to Irving St. (approx.150 ft. of floodwall). The Robinson's Branch left bank, System 3 extends from New Church St. downstream to high ground on the right bank of the Rahway river near Whittier St. (approx. 3,900 ft. of levee/floodwall). Other features included in this plan are four road closure gates located at Central Ave, Hamilton St., Irving St. and W Gran Ave., and two ponding areas located near Hamilton St. and near Allen St. 5.11.2 Cost Estimate

5.13.2 Cost Estimate

A summary of the costs for Robinson's Branch Alternative 1 is presented in Table 40.

Table 40 Robinson's Branch Alternative 1 Costs	
First Cost	$54,870,400
Interest during Construction	$1,675,068
Total Investment Cost	$56,545,468
Annual investment cost	$2,250,111
O&M	$117,900
Annual Cost	$2,368,000

Price Level: FY2016, 3.125% Discount rate.

5.13.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Robinson's Branch Alternative 1 in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Robinson's Branch Alternative 1 is presented in Table 41. A summary of benefits arising from the implementation of Robinson's Branch Alternative 1 and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 41
Summary of Damages and Benefits for Alternative 1 (Robinson's Branch)

Municipality	Without Project	With Alternative 1	Damage Reduction Benefits
Rahway	$2,695,830	$1,212,550	$1,483,280
Total	**$2,695,830**	**$1,212,550**	**$1,483,280**

Price Level: FY2016, 3.125% Discount rate.

5.14 Robinson's Branch Alternative 2a

5.14.1 Description

Robinson's Branch Alternative 2a consists of nonstructural treatments for structures within the 10% chance of annual exceedance (10-yr floodplain) of Robinson's Branch and the Rahway River in Clark. Nonstructural Flood Proofing measures considered in this project were:

- Dry Flood Proofing. Dry flood proofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure walls. Dry flood proofing measures considered in this screening make the portion of a building that is below the flood level watertight through attaching watertight closures to the structure in doorway and window openings.
- Wet Flood Proofing. Wet flood proofing measures allow flood water to get inside lower, non-living space areas of the structure via vents and openings in order to reduce the effects of hydrostatic pressure and, in turn, reduce flood-related damages to the structure's foundation.
- Elevation (aka. Raise). Elevation involves raising the lowest finished floor of a building to a height that is above the flood level. In some cases, the structure is lifted in place and foundation walls are extended up to the new level of the lowest floor.
- Buyouts. It involves the purchase and elimination of flood damaged structures, allowing owners to move to places away from flood risk.

A structural measure of barriers was also considered:

- Barriers (aka. Ringwall). Barriers such as ringwalls, levees, or berms generally surround the building but are not attached. It is used where the elevation isn't practical or feasible.

Nonstructural measures were evaluated for approximately 90 structures contained in the 10% annual exceedance (10-yr event) flood inundation area for the Robinson's Branch and the Rahway River in Clark Township. All structures will be treated to an elevation of one foot above the 1% annual exceedance event. The completed nonstructural plan for the 10% annual exceedance events are summarized in Table 42.

Table 42 Nonstructural Measures Robinson's Branch						
Nonstructural Flood Proofing Measure	**10% Annual Exceedance (10-yr)**			**1% Annual Exceedance (100-yr)**		
	Residential	**Non-Residential**	**Total**	**Residential**	**Non-Residential**	**Total**
Dry Flood proofing	0	0	0	11	7	18
Wet Flood proofing	1	1	2	2	3	5
Barriers	2	4	6	3	10	13
Raise	13	0	13	188	0	188
Buyout	0	0	0	0	0	0
Total of Structures	16	5	**21**	204	20	**224**

5.14.2 Cost Estimate

A summary of the costs for Robinson's Branch Alternative 2a is presented in Table 43.

Table 43 Robinson's Branch Alternative 2a	
First Cost	$10,018,400
Interest during Construction	$103,512
Total Investment Cost	$10,121,912
Annual investment cost	$402,781
O&M	$0
Annual Cost	$402,800

Price Level: FY2016, 3.125% Discount rate.

5.14.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Robinson's Branch Alternative 2a in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Robinson's Branch Alternative 2a is presented in Table 44. A summary of benefits arising from the implementation of Robinson's Branch Alternative 2a and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 44 Summary of Damages and Benefits for Robinson's Branch Alternative 2a			
Municipality	**Without Project**	**With Alternative 2a**	**Damage Reduction Benefits**
Rahway	$2,695,830	$1,339,930	$1,355,900
Total	**$2,695,830**	**$1,339,930**	**$1,355,900**

Price Level: FY2016, 3.125% Discount rate.

5.15 Robinson's Branch Alternative 2b

5.15.1 Description

Nonstructural measures were evaluated for approximately 430 structures contained in the 1% annual exceedance (100-yr event) flood inundation area of the Robinson's Branch and the Rahway River in Clark Township. The methodology and assumptions used to assign nonstructural treatments to individual structures under Robinson's Branch Alternative 2b were identical to those for Robinson's Branch Alternative 2a. All structures will be treated to an elevation of one foot above the 1% annual exceedance event. The completed nonstructural plan for the 1% annual exceedance events are summarized in Table 42.

5.15.2 Cost Estimate

A summary of the costs for Robinson's Branch Alternative 2b is presented in Table 45.

Table 45 Robinson's Branch Alternative 2b Costs	
First Cost	$39,452,200
Interest during Construction	$1,204,388
Total Investment Cost	$40,656,588
Annual investment cost	$1,617,846
O&M	$28,960
Annual Cost	$1,646,800

Price Level: FY2016, 3.125% Discount rate.

5.15.3 Residual Damages and Benefits

Using HEC-FDA, Average Annual Damages were calculated for the base year and future years with Robinson's Branch Alternative 2b in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2016 fiscal year USACE project evaluation and formulation discount rate of 3.125%. A summary of equivalent annual damages and benefits by affected municipality for Robinson's Branch Alternative 2b is presented in Table 46. A summary of benefits arising from the implementation of Robinson's Branch Alternative 2b and the resulting net benefits and benefit-cost ratio in comparison with other evaluated alternatives are presented in Section 6.0.

Table 46
Summary of Damages and Benefits for Robinson's Branch Alternative 2b

Municipality	**Without Project**	**With Alternative 2b**	**Damage Reduction Benefits**
Rahway	$2,695,830	$633,220	$2,062,610
Total	**$2,695,830**	**$633,220**	**$2,062,610**

Price Level: FY2016, 3.125% Discount rate.

6.0 Comparison of Alternatives

6.1 Summary of Benefits and BCRs

A summary of all damages, benefits, costs, and subsequent benefit-cost ratios for the nine structural and two nonstructural plans evaluated for the Rahway River Basin, NJ study area is presented in Table 47. Cranford Upstream Alternatives 1, 2, 3, 4, 5, 6, 7a and 7b were initially analyzed in FY14. Since alternatives 1, 2, 3, 4, 5, and 7b have negative net benefits, their costs were not updated to FY16 price levels for further analysis.

Table 47 Summary of Benefits and Costs							
Alternative	**Flood Damages**		**Annual Benefits**	**First Cost**	**Annual Cost**	**Net Benefits**	**BCR**
	Without-Project	**With-Project**					
Cranford UpstreamAlternative 1: Lenape Park Detention Basin & Channel Modifications	$9,773,600	$7,499,200	$2,274,400	$91,123,800	$4,096,300	-$1,821,900	0.6
Cranford Upstream Alternative 2: Lenape Park Detention Basin and Nomahegan Park Levees Modifications and Channel Modifications	$9,773,600	$7,423,900	$2,349,700	$90,816,400	$4,074,200	-$1,724,500	0.6
Cranford Upstream Alternative 3: Channel Modifications and Deepening Orange Reservoir	$9,773,600	$4,937,100	$4,836,500	$230,303,600	$10,710,000	-$5,873,500	0.5
Cranford Upstream Alternative 4: Channel Modifications and Orange Reservoir Outlet Modification w/Replacement	$9,773,600	$5,290,900	$4,482,700	$134,726,100	$6,050,600	-$1,567,900	0.7
Cranford Upstream Alternative 4a: Small Channel Modification and Orange Reservoir Outlet Modification w/ Replacement	$9,773,600	$6,070,300	$3,703,300	$69,570,000	$3,177,200	$526,100	1.2
Cranford/Upstream Alternative 5: South Mountain Detention Basin (relocation, road and bridge modifications) and Channel Modifications	$9,773,600	$3,054,700	$6,718,900	$174,019,300	$8,047,600	-$1,328,700	0.8
Cranford/Upstream Alternative 6: South Mountain Detention Basin (relocation, road and bridge modification)	$9,773,600	$4,172,600	$5,601,000	$118,576,200	$5,285,900	$315,100	1.1
Cranford/Upstream Alternative 7a : Nonstructural 10-yr Floodplain	$9,773,600	$8,783,300	$990,300	$19,447,800	$935,300	$55,000	1.1
Cranford/Upstream Alternative 7b: Nonstructural 100-yr Floodplain	$9,773,600	$7,495,800	$2,277,800	$186,935,700	$7,802,700	-$5,524,900	0.3
Cranford/Upstream Alternative 8: Lenape Park Detention Basin and Orange Reservoir Outlet Modification w/Replacement	$9,773,600	$5,755,600	$4,018,000	$113,212,500	$5,061,300	-$1,043,300	0.8
Cranford/Upstream Alternative 9: Lenape Park Detention Basin, Orange Reservoir Outlet Modifications w/Replacement and Channel Modifications	$9,773,600	$5,508,700	$4,264,900	$128,949,300	$5,741,600	-$1,476,700	0.7
Robinson’s Branch Alternative 1: Levees/floodwalls and Channel Modifications	$2,695,800	$1,499,600	$1,196,200	$54,870,400	$2,368,000	-$1,171,800	0.5
Robinson’s Branch Alternative 2a: Nonstructural 10-yr Floodplain	$2,695,800	$1,339,900	$1,355,900	$10,018,400	$402,800	$953,100	3.4
Robinson’s Branch Alternative 2b: Nonstructural 100-yr Floodplain	$2,695,800	$633,200	$2,062,600	$39,452,200	$1,646,800	$415,800	1.3

Cranford Upstream: Alternatives 1, 2, 3, 4, 5a, 7b, project costs at FY 2014 price level, 3.125% discount rate, benefits at FY16 price levels, 3.125% discount rate
Cranford: Upstream Alternatives 4a, 6, 7a, 8, 9, project cost and benefits at FY 2016 price level, 3.125% discount rate
Robinson’s Branch: Alternatives 1, 2a, 2b, project costs and benefits at FY 2016 price level, 3.125% discount rate
Annual Cost includes First Cost, IDC, and O&M

6.2 **Tentatively Selected Plan**

The Tentatively Selected Plan (TSP) combines the highest net benefits from the Cranford Upstream study area with the Robinson's Branch study area. The benefit and costs for the combination of Cranford Upstream Alternative 4a, and Robinson's Branch Alternative 2a are summarized in Table 48.

Table 48 TSP Benefit -Cost Summary

	Cranford Upstream Alternative 4a	Robinson's Branch Alternative 2a	Combined TSP
First Cost	$69,570,000	$10,018,400	$79,588,400
Interest During Construction	$3,790,400	$103,500	$3,893,900
Total Investment Cost	$73,360,400	$10,121,900	$83,482,300
Annual Investment Cost	$2,919,200	$402,800	$3,322,000
O&M	$258,000	$0	$258,000
Annual Cost	$3,177,200	$402,800	$3,580,000
Without Project Damages	$9,773,600	$2,695,800	$12,469,400
With Project Damages	$6,070,300	$1,339,900	$7,410,200
Annual Benefits	$3,703,300	$1,355,900	$5,059,200
Net Benefits	$526,100	$953,100	$1,479,200
Benefit Cost Ratio	1.2	3.4	1.4

Price level FY 2016, 3.125% Discount rate

6.3 Project Performance and Risk Analysis

This study has been conducted in accordance with ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies (USACE, January 3, 2006), which stipulates that the risk analysis for a flood protection project should quantify the performance of all alternatives and evaluate the residual risk, including the consequences of the project's capacity exceedance. Table 49 quantifies the performance of all alternatives in accordance with ER 1105-2-101.

Table 49
Expected and Probabilistic Values of Damage Reduced by Alternative

Alternative	Equivalent Annual Damage			Probability that Damage Reduced Exceeds the Indicated Values		
	Without Project	With Project	Damage Reduced	75%	50%	25%
Cranford Upstream Alt. 1	$9,773,600	$7,499,200	$2,274,400	$1,446,700	$2,216,900	$3,015,200
Cranford Upstream Alt. 2	$9,773,600	$7,423,900	$2,349,700	$1,424,700	$2,235,500	$3,031,600
Cranford Upstream Alt. 3	$9,773,600	$4,937,100	$4,836,500	$2,664,100	$4,407,400	$6,576,600
Cranford Upstream Alt. 4	$9,773,600	$5,290,900	$4,482,700	$2,574,300	$4,104,100	$6,038,700
Cranford Upstream Alt. 4a	$9,773,600	$6,070,300	$3,703,300	$1,986,700	$3,242,800	$4,986,200
Cranford Upstream Alt. 5a	$9,773,600	$3,054,700	$6,718,900	$3,504,100	$6,056,300	$9,168,000
Cranford Upstream Alt. 6a	$9,773,600	$4,172,600	$5,601,000	$2,904,800	$4,992,300	$7,595,500
Cranford Upstream Alt. 7a	$9,773,600	$8,783,400	$990,200	$650,200	$965,900	$1,304,700
Cranford Upstream Alt. 7b	$9,773,600	$7,495,800	$2,277,800	$1,387,800	$2,162,500	$3,054,000
Cranford Upstream Alt. 8	$9,773,600	$5,755,600	$2,192,100	$2,192,100	$3,478,800	$5,293,700
Cranford Upstream Alt. 9	$9,773,600	$5,508,700	$4,264,900	$2,376,200	$3,901,500	$5,867,600
Robinson's Branch Alt. 1	$2,695,800	$1,499,600	$1,196,200	$767,000	$1,141,700	$1,579,600
Robinson's Branch Alt. 2a	$2,695,800	$1,339,900	$1,355,900	$884,500	$1,311,800	$1,784,100
Robinson's Branch Alt. 2b	$2,695,800	$633,200	$2,062,600	$1,273,300	$1,957,300	$2,641,600

Price Level: FY2016, 3.125% Discount rate.

Draft Appendix CI

Hydrology

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

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RAHWAY RIVER BASIN, NEW JERSEY
FLOOD RISK MANAGEMENT FEASIBILITY STUDY

1.0 INTRODUCTION

This Feasibility Study is the second phase of the U.S. Army Corps of Engineers planning process, and follows a favorable Reconnaissance Report and execution of a Feasibility Cost Sharing Agreement (FCSA) between the New York District Corps of Engineers and the non-Federal sponsor. The purpose of the Feasibility Study is to fully evaluate all reasonable solutions to the problems identified during the reconnaissance phase. This Feasibility Report documents the planning, engineering, design and real estate activities required to provide a basis for a decision on Federal participation in the construction of a project. The Feasibility Report is a complete decision document which presents the results of the reconnaissance and feasibility phases, and provides the basis for recommending the: (1) construction of a project, (2) preparation of a Design Memorandum (if necessary), and (3) preparation of the Plans and Specifications during the Pre-Construction Engineering and Design ("PED") phase.

There are two areas of interest for the study of the Rahway River basin: Cranford, NJ and Rahway, NJ. This decision was based upon a report titled "Initial Screening of Flood Damage Reduction and Restoration Opportunities, September 2006", done within the feasibility study by an A/E (URS), determined that there were only two locations that were recommended for a more detailed analysis. This report presents information for both portions of the study. However, the two parts of the study were done separately for the following reasons. Work on the Cranford portion was done first and annual peak flow data was included through Water Year 2009. The work included extensive effort in the development of alternatives. During the analysis of the Cranford alternatives, it was decided to commence work on the City of Rahway portion. By this time two more water years of record were available, including a new large flood event in August 2011 (Tropical Cyclone Irene). The added period of record was included in the City of Rahway analysis (and models were calibrated to Irene). However, it was decided not to redo the Cranford portion of the study with the updated data at this time due to the advanced progress of the alternatives. It is anticipated that a unified hydrologic model will be used for the entire Rahway River basin during the optimization process.

2.0 WATERSHED DESCRIPTION

The Rahway River Basin is located in northeastern New Jersey. It lies within the metropolitan area of New York City and occupies portions of Essex, Union and Middlesex Counties. The entire watershed is approximately 83.3 square miles in area and is roughly crescent or “L”-shaped. Its greatest width is approximately 10 miles in the east-west direction, from the City of Linden to the City of Plainfield. Its greatest length is approximately 18 miles in a north–south direction, from West Orange to Metuchen. A map of the Rahway River basin and the municipalities that make it up is shown on Figure 1.

3.0 PROJECT AREA

The Cranford project area is located along the Rahway River main stem in the Township of Cranford, New Jersey. Flood damages have occurred in the vicinity of Riverside Drive near Kensington and Venetia Avenues (adjacent to the east side of the river) and along Park Drive (adjacent to the west side of the river). Flood damages have also been reported along Casino Avenue, off of Riverside Drive, southeast from the major problem area just described. Approximately 300 homes in these areas were affected during Tropical Storm Floyd (September 1999), with basement flooding and flooding above the first floor elevation. The Cranford area was also impacted from the April 2007 Nor’easter and Tropical Cyclone Irene (August 2011). The Rahway project area is located along the Rahway River main steam and Robinsons Branch in the City of Rahway. Flood damages also occurred within the City of Rahway from Tropical Storm Floyd, April 2007 Nor’easter and Tropical Cyclone Irene (August 2011). The project area is shown in Figure 2A for the Cranford portion and Figure 2B for the City of Rahway section.

4.0 CLIMATOLOGY

4.1 Climate

The climate of the Rahway River basin is characteristic of the entire Middle Atlantic Seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate in both temperature and snowfall. The summers are moderate, with hot sultry weather in mid-summer, and with frequent thunderstorms. Rainfall is moderate, and well-distributed throughout the year. The relative humidity is high.

4.2 Precipitation Stations

Stations that were used for historic precipitation records in this study includes:

Rainfall Station: Canoe Brook; Lat/Long: 40^o 45’N74^o02’W; Elev: 180 feet

Rainfall Station: Newark Airport; Lat/Long: 40^o 41’N74^o10’W; Elev: 7 feet

Rainfall Station: Cranford; Lat/Long: 40^o 39’N74^o18’W; Elev: 75 feet

Rainfall Station: Plainfield; Lat/Long: 40^o 36’N74^o24’W; Elev: 90 feet

The impact that these stations have on the Rahway River Watershed during different historic storm events is given below.

For the April 2007 Nor’easter (April 15 to 16, 2007), the Thiessen polygons with the selected rainfall gages are shown in Figure 3. For Tropical Storm Irene (August 27 to 28, 2011), an ArcGIS Grid of precipitation values for the study area was constructed using data from the National Weather Service’s (NWS) Advanced Hydrologic Prediction Service (AHPS). Daily observed precipitation values for 27 to 28 August, 2011(EDT) were merged to produce rainfall totals for the basin. This product was then checked against published National Weather Service totals for this event. The NWS observed precipitation products provide multisensor rainfall estimates, derived from radar, gage, and satellite inputs, in a gridded shapefile format with a resolution of roughly 2.49x2.49 miles. A table depicting rainfall distribution, created from shapefile data, within the Rahway River Watershed is presented in Table 1 (c).

4.3 Annual (Daily) and Monthy Precipitation

The mean annual precipitation in the Rahway River Watershed is approximately 50.94 inches from the 1971-2000 Monthly Normals for the Cranford, New Jersey Station. The observed highest daily value at this station was 9.76 inches (Floyd). The monthly extremes were 13.96 inches in July 1975 and 0.45 inches in November 1976. The distribution of precipitation throughout the years is fairly uniform with highest amount occurring during the summer months. The mean annual snowfall is 20.00 inches at Cranford, New Jersey, precipitation station.

4.4 Storm Types

The storms which occur over the northeastern states have their origins in or near the Pacific and the North Atlantic oceans and may be classified as: extratropical storms; which include thunderstorms, and cyclonic (transcontinental) storms; and tropical storms which include the West Indies hurricanes. There are also nor'easter storms. An extratropical storm, caused by rapid convective circulation that occurs when a tropical marine air mass is lifted suddenly on contact with hills and mountainous terrain, causes heavy rains usually in the summer and fall seasons. The thunderstorms, due to rapid convective circulation, usually occur in July, and are limited in extent and cause local flooding on "flashy streams". Cyclonic storms, due to their transcontinental air mass movement with attendant "highs" and "lows," usually occur in the winter or early spring, and is a potential flood-producer over large areas because of its widespread extent. The West Indies hurricanes of tropical origin proceed northward along the coastal areas, accompanied by winds greater than 75 miles per hour and torrential rains of several days duration.

4.5 Past Storms/Historical Floods

A review of storms which have occurred in the northeastern states reveals that the Rahway River basin is located in the center of the North Atlantic storm belt. Some of the notable storms which which have caused flooding conditions in the basin occurred on or between the following dates: 20-24 September 1882, 30 July 1889, 31 July 1901, 25-26 August 1933, March 1936, 17-25 July 1938, 6-8 August 1938, 17-21 September 1938, 9-16 August 1942, 20 May 1943, 18 September 1945, 28 June 1946, 23-25 July 1946, 8 November 1947, August 1955, October 1955, September 1960, 12-13 March 1962, 21-22 September 1966, 28-29 May 1968, 26-28 August 1971, 13 September 1971, 2-3 August 1973, July 1975 and November 1977. The interested reader can find brief descriptions of the following major flood- producing storms in the Rahway River basin presented in the *General Design Memorandum, Robinson's Branch of the Rahway River at Rahway, New Jersey Flood Control Study*, Volume 2, dated February 1986: (November 1977, July 1975, August 1973, August 1971, August 1969, May 1968 and July 1938). Two large, more recent storms, and the floods that they produced, were used to calibrate the HEC-HMS hydrologic model of the Rahway River basin. Detailed descriptions of these events are given below. A new flood of record occurred after model calibration for the Cranford portion of the analysis. This was Tropical Cyclone Irene (8/28/2011). A description of this event is included below.

4.5.1 Tropical Storm Floyd

The eye of Floyd made landfall on 16 September 1999 near Cape Fear, North Carolina with Category 2 winds of 105 mph. After crossing eastern North Carolina and Virginia, Floyd weakened to a tropical storm. Its center then moved offshore along the coasts of the Delmarva Peninsula and New Jersey. On 17 September, the center of Floyd moved over Long Island NY (making landfall again roughly at the Queens-Nassau counties border) and New England, where it became extratropical.

Precipitation from the storm preceded its center in the New York City area on 15 September. Rainfall totals from Floyd were as high as 12 to 16 inches over portions of New Jersey, 4 to 8 inches over southeastern New York, and up to 11 inches over portions of New England. The inland flooding from Floyd was a disaster of immense proportions in the Eastern United States, particularly in North Carolina. The 56 USA direct deaths due to Floyd is the largest hurricane death toll since Agnes caused the deaths of 122 people in 1972. Total USA damage estimates range from three to over six billion dollars.

Floyd resulted in new flood peaks of record at sixty or more stream gages within the portions of New Jersey and New York contained by New York District's civil works boundaries. Within the Rahway River basin, the total rainfall at Cranford, NJ was 10.82 inches. Tropical Storm Floyd produced a peak flow at the Springfield USGS gage of 7990 cfs and a peak flow of 5590 cfs at the Rahway USGS gage.

4.5.2 April 15-16 2007 Nor'easter

The 15-16 April 2007 nor'easter dropped about three to ten inches of rain on the watersheds within the New York District's civil works boundaries between the early morning of Sunday 15 April 2007 and the early afternoon of Monday 16 April 2007, resulting in new flood peaks of record at ten USGS gages in New Jersey. This storm had the greatest flooding impact on the Raritan and Passaic River basins. It produced the worst flooding in the Raritan River basin since Tropical Storm Floyd during September 1999. Bound Brook and Manville were once again hit hard, as were communities on the other side of the Raritan River in Middlesex County. Lincoln Park in the Passaic Basin was also hit hard.

The approximate time distribution of the total rainfall of the 15-16 April 2007 nor'easter over the watersheds of the New York District was an average of 7 to 7 ½ inches between about 2 a.m. on Sunday 15 April to 2 p.m. on Monday 16 April 2007, with most within the 24 hours beginning at 2 a.m. on Sunday the 15th. Greatest hourly amounts were from 0.6 to 0.8 inches at about 2 p.m. on Sunday 15 April 2007.

Unlike Tropical Storm Floyd, which broke the summer 1999 drought and fell on dry ground, the April 2007 nor'easter caused as much flooding as it did because it was preceded by the smaller 1-2March and 12-13 April 2007 storms, and fell on saturated ground.

The nor'easter had a drop in central pressure of 0.83 inches in 24 hours, which qualified it as a meteorological bomb, a drop in central pressure of at least 0.71 inches in 24 hours. The lowest central pressure of about 28.53 inches is near the border of the pressure defined Categories 2 and 3 once used on the Saffir-Simpson Hurricane Scale.

Within the Rahway River basin, the total rainfall at Cranford was 6.47 inches. This nor'easter produced a peak flow at the Springfield USGS gage of 5540 cfs and a peak flow of 4910 cfs at the Rahway USGS gage.

4.5.3 Tropical Cyclone Irene

Tropical cyclone Irene began as a tropical wave off the West African coast on 15 August 2011. The storm was upgraded into Tropical Storm Irene at 23:00 UTC on 20 August about 190 miles east of Dominica in the Lesser Antilles. On 22 August Irene made landfall near Punta Santiago, Humacao, Puerto Rico, with estimated sustained winds of 70 mph. Just after its initial landfall, Irene was upgraded to a Category 1 hurricane, the first of the 2011 Atlantic hurricane season.

Moving erratically through the southeast Bahamas over very warm waters, Irene quickly expanded as its outflow aloft became very well established. The cyclone intensified into a Category 3 hurricane. Early on 27 August, Irene weekened to a Category 1 hurricane as it approached the

Outer Banks of North Carolina. At 7:30 am EDT the same day, Irene made landfall near Cape Lookout, on North Carolina's Outer Banks, with winds of 85 mph. Later on 27 August, Irene re-emerged into the Atlantic near the southern end of the Chesapeake Bay in Virginia. At about 09:35 UTC on 28 August, Irene made a second landfall at the Little Egg Inlet on the New Jersey shore with winds of 75 mph, and soon after moved over water again. Hours later, Irene weakened to a tropical storm with winds of 65 mph near New York City. Irene then moved northeast over New England, becoming post-tropical over the state of Maine at 11:00 pm EDT.

Significant damages occurred in North and Central New Jersey, where flooding was widespread. Severe river flooding took place on the Raritan, Millstone, Rockaway, Rahway, Delaware, and Passaic Rivers due to record rainfall. The highest rainfall recorded in the state was in Freehold (11.27 inches), followed by Jefferson (10.54 inches) and Wayne (10.00 inches). The flooding affected roads, including the heavily used Interstate 287 in Boonton where the northbound shoulder collapsed, the Garden State Parkway which flooded in Cranford from the Rahway River and in Toms River near exit 98. Along the Hudson River, in parts of Jersey City and Hoboken, flood waters rose as much as 5 feet and the north tube of the Holland Tunnel was briefly closed. In total, ten deaths within the state are attributable to the storm.

In addition to major flooding, the combination of already heavily saturated ground from a wet summer, and heavy wind gusts made trees in Union County especially vulnerable to wind damage. Fallen trees, many pushed from the soaked ground with their roots attached, blocked vital roads from being accessed by local emergency services. Numerous homes suffered structural damages from the winds, and limbs impacting their roofs. Perhaps the most critical damage however due to wind was fallen wires. Around Union County, fallen wires in combination with flooded electrical substations left parts of Union County, including Cranford, Garwood, and Westfield without power or phone service for nearly a week. In total, approximately 1.46 million customers of Jersey Central Power and Light (JCP&L) and Public Service Electric and Gas (PSEG) throughout most of the 21 counties lost power.

On 29 August, the governor of New Jersey asked President Obama to expedite release of emergency funds to the state. Eventually all 21 New Jersey counties became eligible for FEMA aid.

5.0 HYPOTHETICAL RAINFALL

A 48-hour duration hypothetical storm was modeled so that the Rahway River basin-wide HEC-HMS model developed for this study would be accurate for times of concentration as large as 24 to 48 hours.

Specific frequency point precipitation estimates in inches were obtained for the Rahway River basin from “Precipitation-Frequency Atlas of the United States” NOAA Atlas 14, volume 2. The precipitation frequency estimates are based on an annual maximum series. The data was determined at Cranford, NJ (40.65N, 74.30W) as a representative basin location.

Point rainfall depths were part of the HEC-HMS model input and were converted to finite area rainfall depths with transposition storm areas and procedures contained in HEC-HMS. A time step of 5 minutes was used for the HEC-HMS models because of the sizes and times of concentration of the HEC-HMS model subbasins. The time series data of the hypothetical storms modeled is therefore given in 5 minute increments. The hypothetical point rainfall data for both project areas are given in Tables 1A & 1B. A storm area of 83.13 square miles was used to reduce point rainfall values to finite drainage area values, because it is the drainage area of the Rahway River at its mouth.

6.0 STREAMFLOW

6.1 Peak Discharge Records

There are, at present, three active continuous record USGS stream gages in the Rahway River basin. The most upstream gage is USGS gage number 01394500, Rahway River near Springfield, NJ. The gage is located on the left bank of the Rahway River, 50 feet downstream from the bridge on eastbound U.S. Highway 22, 100 feet downstream from Pope Brook and 1.50 miles south of Springfield. The drainage area at the gage is 25.50 square miles and the period of record is from July 1938 to the current year. The next gage is USGS gage number 01395000, Rahway River at Rahway, NJ. The gage is located on the left bank of the Rahway River, 100 feet upstream from the bridge on St. Georges Avenue in Rahway, 0.90 miles upstream from the confluence with Robinsons Branch, and 1.70 miles southwest of Linden. The drainage area at the gage is 40.90 square miles and the continuous period of record is from October 1921 to the current year. A third stream gage is USGS gage number 01396000, Robinsons Branch at Rahway, NJ. The gage is located on the right bank of Robinsons Branch, 70 feet upstream of the dam on Milton Lake, 0.40 miles upstream from Maple Avenue at Milton Lake in Rahway, 0.60 miles downstream from Middlesex Reservoir Dam, and 1.60 miles upstream from the mouth. The drainage area at the gage is 21.60 square miles. The gage was a continuous-record gaging station, water years 1937-96. It has been an annual maximum station, water years 1999 to the current year. The Springfield and Rahway gages were used to calibrate the HEC-HMS hydrological model used in this analysis for the Cranford project area and all three gages were used for the City of Rahway project area. The records of these USGS gaging stations are published in the Water-Data Reports of the U.S. Geological Survey. The locations of these stream gages are shown on Figure 4.

6.2 Average Discharge

The average annual runoff of the Rahway River basin at the USGS gage near Springfield is 31.40 cfs over the 25.50 square mile drainage area for water years 1939-2009 inclusive or 1.23 cfs per square mile (csm). At the USGS gage at Rahway, the average annual runoff is 50.0 cfs for water years 1922-2009 inclusive over the 40.90 square mile area or 1.23 cfs per square mile (csm). At the USGS gage on Robinsons Branch, the average annual runoff is 22.60 cfs for water years 1939-1980 inclusive over the 21.60 square mile area or 1.05 cfs per square mile (csm).The runoff is equal to an equivalent depth of 16.70 inches per year over the watershed at Springfield and Rahway and 14.20 inches at Robinsons Branch. The average Rahway River basin annual rainfall is 50.94 inches. The runoff at Rahway is equivalent to 32.80 percent of this rainfall.

7.0 HYDROLOGIC MODEL

The Hydrologic Modeling System software (HEC-HMS), developed by the Hydrologic Engineering Center, Davis, CA, was used to hydrologically model the Rahway River basin. The HEC-HMS model was converted from a HEC-1 model originally developed by the New York District for previous Rahway River basin studies that focused on Springfield (1984) and Robinson's Branch (1985-6). Figure 4 shows the Rahway Watershed with subbasins and Figure 5 shows a schematic diagram of the HEC-HMS model. Table 2 give the name of each element, its description, the drainage area at that point and the type of computation. Subbasin data that includes unitgraph parameters and percent impervious area for both project areas are presented in Tables 3A &3B. Several methods of channel routing are utilized in the various stream reaches.

Table 4 gives values of Muskingum travel time, K and inflow-storage factor X for those reaches that utilize that method as well as values of lag used in the lag routing method encountered in certain other reaches. Modified Puls routing, using storage-outflow data developed from calibrated historic flood event runs with HEC-RAS, was used where possible. These relations are shown in Figures 5a through 5e. In addition, a reservoir computation was utilized at Lenape Park Dam, Orange Reservoir, Campbell Pond Dam and Diamond Mill Pond. This involved the development of storage vs discharge and elevation vs storage relationships to perform the routings. Plots of this data are shown in Figures 5f and 5g.

8.0 RECENT LARGE HISTORIC FLOOD CALIBRATION

Different HEC-HMS models were developed for the two project areas: the Township of Cranford and the City of Rahway. The hydrologic analysis for the Cranford project area was completed and was calibrated to the April 2007 event (**4.5.2**) using HEC-HMS. The hydrologic analysis for the City of Rahway project area was completed and was calibrated to the August 2011 event (**4.5.3**). For the 15-16 September 1999 flood event (**4.5.1**), the analysis was abandoned because it did not lead to successful matching of the floodmarks for the HEC-RAS model of this event. For more information, please see the discussion presented in the Existing Conditions Hydraulic Appendix.

For the Cranford project areas, the model was calibrated to data from two USGS stream gages on the Rahway River. These two stream gages analyzed flow records through Water Year 2009. The most upstream stream gage was the Rahway River near Springfield, NJ. The most downstream stream gage was the Rahway River at Rahway, NJ. To calibrate the model to data at the Springfield gage, adjustments were made to the constant infiltration loss rate of rainfall. Calibration to the Rahway gage involved constant loss rate adjustments for the drainage areas between the Springfield and Rahway gages, once the calibration to the Springfield gage was done. Initial loss and constant loss rates used in this calibration are shown in Table 5. Adjustments were then made to the Modified Puls storage-outflow routing relations between the Springfield and Rahway gages. Observed and computed hydrographs, with their associated hyetographs, for the calibration floods at the stream gages are shown in Figures 7 through 8.

For the City of Rahway project area, all three stream gages analyzed flow records through Water Year 2011, which included the major event of Tropical Cyclone Irene during August 2011, to which it was calibrated. Calibration to all three gages involved constant loss rate adjustments for the drainage areas between the three gages. Initial loss and constant loss rates used in this calibration are also shown in Table 5. Adjustments were then made to the Modified Puls storage-outflow routing relations between the Springfield and Rahway gages. Observed and computed hydrographs, with their associated hyetographs, for the calibration floods at the stream gages are shown in Figures 9 through 11. It is also acknowledged that basin-wide results will be different for the two HMS models used in Cranford and Rahway.

It is noted, during optimization one set of flows will be used for both project reaches (that derived from the calibration to Tropical Cyclone Irene). The results of the calibration runs to April 2007 nor'easter and Tropical Cyclone Irene (August 2011) can be reviewed in the peak discharges presented in Table 6.

9.0 FLOOD FREQUENCY ANALYSIS: EXISTING CONDITIONS

Computations were performed at three USGS stream gages within the Rahway River basin to determine the existing conditions peak flow vs. frequency relations. For the annual series curve, a program developed by the Hydrologic Engineering Center, Davis, CA: HEC-SSP was utilized. The upstream limit and calibration point of the study, the USGS gage on the Rahway River near Springfield, NJ is the first gage to be analyzed. The annual peak flow data at this gage is a product of USGS peak gage heights and a Corps of Engineers rating used in the New York District 1984 Springfield hydrology appendix. This data is shown in Tables 7(a), 7(b) and 7(c). Another gage used in the analysis is the USGS gage on the Rahway River at Rahway, NJ. This is the downstream limit and calibration point of the Cranford study. All the peak flows used at this gage represent the post construction condition of the Lenape Park detention basin. A pre to post Lenape Park peak flow conversion for specific-frequency hypothetical floods was used from the New York district 1984 Springfield hydrology appendix was used to convert pre-Lenape Park Rahway River at Rahway historic annual peak flows to a post-Lenape Park condition. This data is shown in Tables 8(a), 8(b) and 8(c). The third USGS stream gage used was Robinsons Branch at Rahway, NJ. This data is shown in Table 9(a) and (b). This gage was used for the City of Rahway Analysis only. Gaged data through Water Year 2009 was used for the Cranford analysis. Gaged data through Water Year 2013 was used for the City of Rahway analysis.

A partial duration adjustment was made to the annual series curves to reflect the occurrence of all flows above an established base during a given year. A utility program that employed Weibull plotting positions was used for this calculation. A two-week separation interval was used to remove all dependent partial peak flows from the analysis. Figures 12, and 13 show the adopted peak flow vs. frequency curves at the USGS gages up to WY2009 and Figures 14 through 16 show the adopted peak flow vs. frequency curves at the USGS gages up to WY2013.

10.0 EXISTING CONDITIONS PEAK DISCHARGE: SPECIFIC-FREQUENCY HYPOTHETICAL FLOODS (CALIBRATION & COMPUTATIONS)

Frequency-specific modifications to the existing conditions HEC-HMS hydrologic models were made to model specific-frequency hypothetical floods. The driving input for these modifications is hypothetical rain data. Point precipitation frequency estimates were obtained from NOAA Atlas 14 (partial duration series) and are shown in Tables 1A and 1B. For the Cranford project area, calibration of this model for the Springfield and Rahway stream gages, used the values in Table 1A. For the City of Rahway project area, calibration for this model used all three gages (including the Robinsons Branch gage), used the values in Table 1B. The initial loss and constant loss rates used for this calibration are shown in Tables 10A for Cranford and 10B for the City of Rahway project areas. The difference for the hypothetical events is that the models were calibrated to the peak flows computed in the existing conditions flood frequency analysis discussed above rather than observed hydrographs as was the case with the historic flood events. A range of calibrated existing conditions hypothetical flood peaks is presented in Table 11 for the relevant points of interest in the Rahway River basin for the Cranford study and in Table 12 for the City of Rahway. Hydrographs of the 10-year and 100-year events within the Cranford project area are shown in Figures 17 and 18 and within the City of Rahway project area are shown in Figures 19 through 22.

11.0 FUTURE UNIMPROVED CONDITIONS HYPOTHETICAL PEAK DISCHARGES

Insufficient data concerning projected future land use in the Rahway River basin municipalities was available to modify the HEC-HMS hydrological model for future unimproved conditions hypothetical discharge calculations. Because the Rahway River basin is so thoroughly developed at the present time, an alternate method was adopted to expedite the analysis while producing a reasonable answer. A “worst case scenario” assumption was made that all golf courses and country clubs in the basin would, in the future, become residentially developed at the same density (average lot size) as adjacent existing residential areas. Areas were measured using a GIS program called ArcMap 9.3. Percent impervious area (RTIMP) of adjacent existing residential areas was determined from their average lot size using a relation in NRCS publication *TR-55 (Urban Hydrology for Small Watersheds)* as shown in Table 13. Future values of HEC-HMS model subbasin percent impervious area (RTIMP) values were then calculated according to this assumption. These values are shown in Table 14.

HEC-HMS model subbasin Clark unit hydrograph input parameters Tc and R were predicted to change in response to an increase in their RTIMP values according to regression equations for Tc and R as a function of subbasin drainage area, slope, and RTIMP, contained in Special Projects Memo 469, *Hydrologic-Hydraulic Simulation: Rahway River Basin New Jersey*, U.S. Army Corps of Engineers, Hydrologic Engineering Center, November 1976. Subbasin drainage areas and slopes were assumed to remain the same from existing to future conditions. Future to existing ratios of $(1 + 0.03\ \mathrm{RTIMP})^{-1.28}$ factors were then found for each subbasin and applied to existing conditions values of Tc and R for each subbasin to compute future conditions values of Tc and R which can also be found in Table 14.

Future values of subbasin RTIMP, and Clark unit hydrograph Tc and R, so computed were input to the HEC-HMS models of the Rahway River Basin. The models were then run with no other changes. Values of future unimproved conditions peak discharges at Cranford and the City of Rahway project areas are shown in Tables 15 and 16.

12.0 RISK AND UNCERTAINTY

The procedure followed to determine the equivalent record length, and 95 % and 5 % confidence limits, for the existing conditions specific frequency hypothetical peak discharges, was taken from Chapter 4, Uncertainty of Discharge-Probability Function, of EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, 1 August 1996. A computer based program (i.e., HEC-SSP) was used to generate the peak discharge vs. frequency curves at the three USGS stream gages using Log-Pearson Type III analysis.

To determine the equivalent record length for the three gages, the table within EM 1110-2-1619 (Table 4-5, Page 4-5 of Chapter 4) was used. This table gives equivalent record length based on the method of frequency function estimation. The systematic record length of the long-term hydrologic calibration points for this study is given for the following three gages: USGS gage # 01394500, Rahway River near Springfield, NJ is 75 years, water years 1938-2013 inclusive, USGS gage # 01395000, Rahway River at Rahway, NJ is 91 years, water years 1922-2013 inclusive, and USGS gage # 01396000, Robinsons Branch at Rahway, NJ is 71 years, water years 1940-2013 inclusive. These systematic record lengths were used to determine the confidence limits of the hypothetical peak flows for these gages.

Chapter 4 of EM 1110-2-1619 cites Appendix 9: Confidence Limits, of Bulletin # 17B, Guidelines For Determining Flood Flow Frequency, as the source of the procedure used to compute confidence limits for hypothetical peak flows. This procedure was followed in this study. It requires the logarithmic standard deviation, equivalent record length, and frequencies of the hypothetical peak flows at a given point of interest.

The peak discharge vs frequency curve, that uses observed annual peak discharges at a given USGS gage, has three defined curve. The first curve is called the "expected value" curve. This curve represents the actual peak flows that is used in the hydrology analysis and hydraulic analysis for existing (current) conditions. These values are shown in Tables 11 and 12. The second curve is the "95 % curve (95% confidence limit)". This is the lower limit curve and it is defined as the 95 % probability that the actual value of the specific-frequency peak discharge, at a given probability (i.e., 1% (100-year event) annual chance exceedance (ACE)), is above the 95 % limit value. The third curve is the "5 % curve (5% confidence limit). This is the upper limit curve and it is defined as the 5 % probability that the actual value of the specific-frequency peak discharge, at a given probability, is above the 5 % limit value. Just for clarity, if we draw a line up from the x-axis (probability scale) at the 1% ACE and through the three curves, this means that there is a 95 % - 5 % = 90 % chance that the actual value of the 100 year peak discharge is between the 95 % and 5 % confidence limits.

The peak discharge vs. frequency curve at the three gages and other selected locations are plotted on Figures 12 through 16 for existing conditions.

13.0 IMPROVED CONDITIONS

13.1 Introduction

The improved condition alternatives that are being studied can be found within the Hydraulics Appendix. Most of the "improved conditions" plans are being done within hydraulics because the attenuation of the discharge hydrographs will be done in unsteady HEC-RAS, where the structural components of these alternatives will be developed. Table 17 shows a list of structural alternatives looked at within the hydraulic analysis. The only input needed from hydrology is the existing conditions discharge hydrographs at selected input locations within the unsteady HEC-RAS model. These input locations are basically subbasins within the Rahway Watershed. There are a total of 30 subbasins within this watershed that hydrograph input is used in the unsteady HEC-RAS model. The only major tributary that is not modeled within the unsteady HEC-RAS model is the East Branch of the Rahway River. The East Branch of the Rahway River is approximately 8.11 square miles (includes subbasins SAD, SAE and SAF) and it entered within the unsteady HEC-RAS model as input hydrographs.

For all structural alternatives that was looked at within Improved Conditions, Orange Reservoir and South Mountain Dry Detention Basin was analyzed and computed with HEC-HMS and peak discharges for each return period was provided for HEC-RAS analysis . All alternatives based upon Orange Reservoir or South Mountain Dry Detention Basin is explained in the next section.

13.2 Orange Reservoir/South Mountain Dry Detention Alternatives

For all of the Orange Reservoir/South Mountain Dry Detention Alternatives, the HEC-HMS model that was used for unimproved conditions discharge estimates was modified using information obtained from improved conditions runs of the HEC-RAS model. Flow, elevation and storage values for each flood event within the HEC-HMS model was compared to the runs of the HEC-RAS model for Orange Reservoir and South Mountain Dry Detention Basin to determine if the reservoir elevations and discharge from the reservoirs are acceptable. Tables 18 (a) & (b) shows the discharge vs. elevation and storage vs. elevation for both locations. Figure 5 (f) shows the Orange Reservoir data in graphical form. Table 19 shows the HEC-HMS results for existing conditions of Orange Reservoir and the modification of Orange Reservoir alternative. Table 20 shows the HEC-HMS results for the South Mountain Dry Detention Basin alternative. Conceptual layout of the Orange Reservoir and South Mountain Dry Detention Basin Alternatives are further described within the Hydraulic Appendix.

14.0 PMF ANALYSIS

14.1 Introduction

A Probable Maximum Flood (PMF) analysis was done to compute the PMF peak discharges needed to correctly size the dam structures within the alternatives studied for the Township of Cranford and City of Rahway. Application of the PMF is usually confined to the determination of spillway size and stability requirements for high dams, and considerations of the consequences of sudden and catastrophic failure of such structures. The three structures necessitating the modeling and study of the PMF for this feasibility study are the Orange Reservoir and Dam, the Lenape Park Detention Basin and Dam, and the Middlesex Reservoir and Dam.

Orange Reservoir and Dam are located on the West Branch of the Rahway River in the northwestern most headwaters of the Rahway River Basin in the Village of Orange, N.J. They were originally constructed for municipal water supply.

Middlesex Reservoir and Dam are located on Robinson's Branch of the Rahway River just west of the City of Rahway, NJ, near the center of the Robinson's Branch watershed. They were originally constructed for municipal water supply.

The Lenape Park Detention Basin was originally a Corps design for flood damage reduction in the town of Cranford New Jersey, but was built by locals in 1980. It is located on the Rahway River upstream of its confluence with Nomahegan Creek in the town of Cranford New Jersey. See NY District COE flood damage reduction study for Rahway River Basin, and Van Winkles Brook, Springfield NJ for further details.

The PMF is, by definition, the flood produced in the study basin by the Probable Maximum Storm (PMS). The PMS is defined as the storm that represents the most severe flood-producing rainfall depth-area-duration relationship and isohyetal pattern considered reasonably possible for the region in which the study basin is located. The Probable Maximum Precipitation (PMP) is theoretically the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year.

Study of the PMS and PMF is required by COE regulations (ER 1110-8-2 (FR)) if a structure six feet or higher is proposed to impound flood water as part of a flood damage reduction measure.

14.2 Development of PMF using HEC-HMS

14.2.1 Update of base HMS model for PMF run

A HEC-HMS 4.0 model of the PMF for the Rahway River basin was created by using the 100 year hypothetical flood event as a base. The PMF model was modified and augmented in three ways to prepare it for input of the Probable Maximum Storm over the Rahway River basin, as computed by program HMR-52 (Probable Maximum Storm-Eastern United States). The first augmentation is that the storage-discharge functions of the Modified Puls routing reaches of the HEC-HMS model of the Rahway River Basin were linearly extrapolated upwards to accommodate the anticipated extremely high peak flows of the PMF in the Rahway River Basin. The elevation-storage functions of the Orange Reservoir and Dam, and the Middlesex Reservoir and Dam, were also linearly extrapolated upward for the same reason. The extrapolated Corps data for these two reservoirs, and their dams, was later replaced by data from the NJDEP A/E PMF studies of the Orange and Middlesex Reservoirs and Dams. For the Lenape Park Dam, extrapolation was not necessary to attenuate the PMF.

The second augmentation is that the Clark unit hydrographs of the subbasins of the Rahway River Basin HEC-HMS model were made 25 percent more peaked by decreasing their values of Tc and R by 25 percent. This was done to comply with the ER 1110-2-8 (FR) (page 3, Section 8.b). This regulation requires this for study of the PMF, because watersheds become more efficient flood peak producers in extremely large floods such as the PMF. This is because under the PMF, portions of the watershed's flood plains not usually inundated, ARE inundated by the PMF, to an exceptionally large depth that makes them more efficient flood peak producers, than would be the case under smaller floods. Both the original, and 25 % more peaked, subbasin unit hydrograph Clark Tc and R values for the entire Rahway River Basin are summarized in Table 21.

The third augmentation is that the initial rain infiltration loss and constant loss rate of the subbasins were set to conservatively low values of1.00 inch, and 0.05 inch per hour, respectively. This is based upon the assumption that the ground is saturated during the Probable Maximum Storm.

14.2.2 Development of PMP and PMS using HMR 52

Development of the PMP is taken from the NOAA Publication HMR-51 (Probable Maximum Precipitation Estimates – United States East Of the 105th Meridian, U.S. Department of Commerce, NOAA, Silver Spring, Md. 1978, Figures 19 through 48), and the rainfall depth is in inches for durations of 6, 12, 24, 48 and 72 hours (based upon storm areas of 10, 200, 1000, 5000, 10,000 and 20,000 square miles). The PMP values are summarized in Table 22.

After the PMP values are determined, the next step is to determine the PMS. The location of the PMS within the Rahway River Basin is based upon the dam that are selected to be part of the improved condition alternatives. The three dams that PMS will be developed for are: 1) West Branch Rahway River at Orange Reservoir Dam (appox. 4.61 sq mi of drainage area from the dam); 2) Rahway River at Lenape Park Detention Basin Dam (approx. 30.87 sq mi of drainage area from the dam); and Robinson's Branch Rahway River at Middlesex Reservoir Dam (approx. 20.83 sq. mi of drainage area from the dam). Three PMF's will be generated from these three dam locations. There will be two additional locations chosen to come up with the PMS (Rahway River upstream of Robinson's Branch which is approx. 41.61 sq mi of drainage area at its confluence and Rahway River at mouth (Arthur Kill) : 83.13 sq mi. of drainage areas at its mouth). These two additional locations were chosen to create a final PMF that will be called "Four Centering". The reason for this additional PMF is to determine the maximum PMS for the entire watershed. The results will be used to determine if the PMF's developed at the three dam locations are under the "Four Centering" PMF results. The PMF results from this run would be the "worst case scenario" of PMF within the watershed.

The PMS isohyets are nineteen ellipses, labeled A through S, with a major to minor axis ratio of 2.5, enclosing standardized areas of 10 to 60,000 square miles (Publication HMR-52, Figure 5). Program HMR-52 maximizes the PMS over the study basin by computing it for varying storm orientations and storm areas, with the center of the isohyetal pattern at the centroid of the watershed for which the PMS is to be maximized. With storm area held constant, the PMS is maximized for a watershed when the major, or long, axis of the isohyetal pattern coincides with the axis about which the critical PMS watershed has the least area moment of inertia. The long or major axis of the isohyetal pattern is also the axis about which it has the least area moment of inertia. This ensures that the most PMS rainfall is placed over the most drainage area of the study watershed as possible.

Assuming that the storm orientation remains fixed, the computed PMS for a given watershed varies with the storm area (a function of watershed size). Another factor in the computation is the amount of total precipitation concentrated toward the center of the isohyetal pattern. For example, a 60,000 square mile storm would have its total rainfall spread out more or less uniformly within the "S" isohyet enclosing it. By contrast, a 10 square mile storm would have most of its rain concentrated within the 10 square mile "A" isohyet, with very little outside of it. The total rain of the 10 square mile storm would be much greater than that of the 60,000 square mile storm, because, with duration held constant, PMP tends to decrease with area. Figure 23 shows a sample of the PMS using the "Four Centering" results.

14.2.3 Output from HMR 52

Tables 23 and 24 summarizes the total 72 hour PMS depths in inches for all subbasins relevant to all five of the optimizations and maximizations of the PMS performed in this study for the Rahway River Basin. It also gives the optimized orientations in degrees, storm areas in square miles, and contributing drainage areas in square miles, for the five PMS optimizations and maximizations performed. Table 25 summarizes the maximum rain depths in inches, for selected durations, for all five optimizations and centering of the PMS over the Rahway River Basin listed above.

From the HMR 52 computed results of the PMS, these durations (5 and 15 minutes, 1 hr, 2, 3, 6, 12, 24, 48, 72 and 96 hours), were chosen so that it could be entered into HMS. Within the Meteorological Component section of HMS, it was determined to use the "Frequency Storm" option. Within the Frequency Storm input option, the 96 hour rainfall total depth is required as input. This value was logarithmically extrapolated from the 48 and 72 hour depths computed by HMR 52 for each subbasin using the following formula:

$$\mathbf{D_{96} = D_{72}*(1 + (D_{72}/D_{48}-1)*0.7095)}$$

In which, D_{96} = 96 hour depth in inches; D_{72} = 72 hour total PMS depth in inches; and D_{48} = 48 hour maximum PMS depth in inches

The use of this formula ensures that the maximum 72 hour depth computed by the frequency storm option from the input 48 and 96 hour depths equals the 72 hour total PMS depth in inches computed by program HMR-52, for each subbasin.

14.3 PMF Results from HEC-HMS

PMS rain data computed by program HMR 52, for the three dam locations within the Rahway River Basin (Orange, Lenape Park and Middlesex Reservoirs) and the "Four Centering" location was input into HMS "Frequency Storm" option to develop the four simulation runs of the PMF for the Rahway River Basin. The peak discharges in cfs, and hydrograph volumes in inches, of these four simulation runs, are summarized in Table 26.

RAHWAY RIVER BASIN
ESSEX AND UNION COUNTIES, NEW JERSEY
FLOOD RISK MANAGEMENT PROJECT

HYDROLOGY APPENDIX – TABLES & FIGURES

TABLES 1(A & B): RAHWAY RIVER BASIN POINT RAINFALL DEPTHS IN INCHES FOR HYPOTHETICAL STORMS FROM ON-LINE NOAA ATLAS 14

Table 1A - Cranford - Precipitation Frequency Estimate									
	1-yr	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
5-min:	0.33	0.40	0.47	0.52	0.59	0.63	0.68	0.72	0.77
15-min:	0.67	0.80	0.95	1.06	1.19	1.28	1.36	1.44	1.53
60-min:	1.14	1.39	1.74	2.00	2.35	2.61	2.99	3.14	3.49
2-hr:	1.40	1.70	2.16	2.51	3.00	3.41	3.82	4.26	4.86
3-hr:	1.56	1.90	2.41	2.80	3.36	3.81	4.27	4.76	5.44
6-hr:	2.00	2.43	3.08	3.60	4.36	4.99	5.66	6.38	7.41
12-hr:	2.48	3.01	3.83	4.52	5.54	6.41	7.36	8.41	9.96
24-hr:	2.80	3.39	4.35	5.18	6.42	7.50	8.70	10.02	12.07
2-day:	3.30	4.00	5.11	6.04	7.41	8.58	9.85	11.25	13.32

Table 1B – City of Rahway - Precipitation Frequency Estimate									
	1-yr	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
5-min:	0.34	0.40	0.47	0.52	0.59	0.63	0.68	0.72	0.77
15-min:	0.67	0.80	0.96	1.06	1.19	1.28	1.36	1.44	1.53
60-min:	1.14	1.39	1.74	2.00	2.35	2.61	2.87	3.14	3.49
2-hr:	1.40	1.70	2.16	2.51	3.00	3.41	3.82	4.26	4.87
3-hr:	1.56	1.90	2.41	2.81	3.36	3.81	4.28	4.76	5.44
6-hr:	2.00	2.44	3.08	3.61	4.36	5.00	5.67	6.39	7.41
12-hr:	2.48	3.02	3.84	4.54	5.56	6.43	7.39	8.44	9.96
24-hr:	2.81	3.40	4.37	5.19	6.44	7.52	8.72	10.07	12.07
2-day:	3.31	4.01	5.12	6.06	7.43	8.60	9.88	11.28	13.32

TABLE 1(C): TROPICAL STORM IRENE RAINFALL FROM NWS (MULTISENSOR DATA)

Subbasin Name	Total Storm Precipitation (inches)
101	8.80
102	8.73
103A	8.94
103B	8.97
103C	9.03
107	8.91
110	8.98
113	9.12
115	9.10
117	9.27
119	9.17
122	8.94
126	8.84
129	9.10
201	7.42
203	7.52
206	7.54
ASHBRK	8.82
RAH_N	8.26
RAH_O	8.04
RAH_P	8.03
RAH_Q	7.79
SAA	8.78
SAB	8.49
SAC	8.43
SAD	8.76
SAE	8.81
SAF	8.64
SAG	8.71
SAH	8.47
SAI	8.75
SAJ	8.92
SAK	8.24
SAL	8.44
SAM	8.37

TABLE 2: HEC-HMS MODEL STRUCTURE

Element Name	Element Type	Drainage Area (mi^2)	Description
SAA	Subbasin	4.61	Subbasin “A” - W. Branch Rahway Headwaters
SAA COMP	Junction	4.61	Junction “SAA COMP”
Orange_Res	Reservoir	4.61	Orange Reservoir
AB	Reach	4.61	CHANNEL ROUTE THROUGH SOUTH MOUNTAIN RESERVATION
SAB	Subbasin	2.46	Subbasin “B” – South Mountain Reservation
Junction-1	Junction	7.07	W. Branch Rahway Below South Mountain Reservation
LAGAB	Reach	7.07	Lag Routing of Junction-1 Hydrograph
DSB	Junction	7.07	WEST BRANCH RAHWAY AT MILLBURN BELOW DIAMOND MILL POND
Cam_Pond	Reservoir	7.07	Campbell Pond Dam
Dia_Mill_Pond	Reservoir	7.07	Diamond Mill Pond
BC	Reach	7.07	Route thru Millburn
Junction-2	Junction	7.07	Junction-2
LAGBC	Reach	7.07	Lag routing of Junction-2 Hydrograph
SAC	Subbasin	1.12	Subbasin “C” - Millburn
WESTBR	Junction	8.19	W. BRANCH RAHWAY IMMEDIATELY UPSTREAM OF CONFLUENCE
SAD	Subbasin	2.62	Subbasin “D” – East Branch Rahway Headwaters
SAD COMP	Junction	2.62	Junction “SAD COMP”
DE	Reach	2.62	ROUTE THRU SOUTH ORANGE
SAE	Subbasin	2.21	Subbasin "E" - SOUTH ORANGE
DSE	Junction	4.83	EAST BRANCH AT VILLAGE LINE
EF OLD R	Reach	4.83	ROUTE THRU MAPLEWOOD
SAF	Subbasin	3.28	Subbasin "F" - MAPLEWOOD
EASTBR	Junction	8.11	E. BRANCH RAHWAY IMMEDIATELY UPSTREAM OF CONFLUENCE
EWCONF	Junction	16.30	RAHWAY DOWNSTREAM OF E. AND W. BRANCHES
CFG	Reach	16.30	ROUTE THRU SUBBASIN "G"
Junction-3	Junction	16.30	Junction-3
LAGCFG	Reach	16.30	Lag Routing of Junction-3 Hydrograph
SAG	Subbasin	1.94	Subbasin "G"
DSG	Junction	18.24	RAHWAY AT MILLTOWN
SAH	Subbasin	5.47	Subbasin "H" - VAN WINKLE BROOK AT MOUTH
DSH	Junction	23.71	RAHWAY AT MILLTOWN
HI	Reach	23.71	ROUTE THRU SPRINGFIELD TWP.
SAI	Subbasin	2.84	Subbasin “I”

TABLE 2: HEC-HMS MODEL STRUCTURE (CONT.)

Element Name	Element Type	Drainage Area (mi^2)	Description
SPRDSI	Junction	26.55	COMBINED FLOW AT USGS GAGE NEAR SPRINGFIELD
SAK	Subbasin	4.32	Subbasin “K”
DSK	Junction	30.87	COMBINED INFLOW INTO LENAPE PARK
Lenape_Park_Dam	Reservoir	30.87	Lenape Park Levee System with Hydraulic Structure
SAJ	Subbasin	0.75	Subbasin “J”
Junction-4	Junction	31.62	Junction-4
KL1 OLD	Reach	31.62	ROUTE THRU NOMAHEGAN PARK IN CRANFORD
JCT KL1	Junction	31.62	
KL1 1	Reach	31.62	
Junction-5	Junction	31.62	Damage Center in Cranford
KL2 OLD	Reach	31.62	ROUTE THRU CRANFORD TO NJ CENTRAL RAILROAD
JCT KL2	Junction	31.62	
mus_KL2	Reach	31.62	
SAL	Subbasin	5.46	Subbasin “L”
DSL	Junction	37.08	COMBINED FLOW AT NJ CENTRAL RAILROAD
LM1 OLD	Reach	37.08	ROUTE THRU CLARK TO GARDEN STATE PARKWAY
JCT LM1	Junction	37.08	
mus_LM1	Reach	37.08	
Junction-6	Junction	37.08	Junction-6
LM2 OLD	Reach	37.08	ROUTE THRU CLARK TO USGS GAGE AT RAHWAY
JCT LM2	Junction	37.08	
mus_LM2	Reach	37.08	
SAM	Subbasin	4.11	Subbasin “M”
RAHDSM	Junction	41.19	COMBINED FLOW AT USGS GAGE AT RAHWAY
UPROBR	Reach	41.19	ROUTE HYDROGRAPH AT RAHWAY GAGE TO ROBINSON'S BRANCH CONFLUENCE
RAH-N	Subbasin	0.42	COMPUTE SUBBASIN RAH-N RAHWAY MAINSTREAM RAHWAY GAGE TO ROBINSON'S BRANCH CONFLUENCE
UPROBC	Junction	41.61	COMBINE SUBBASIN RAH-N AND ROUTED HYDROGRAPH OF RAHWAY GAGE AT ROBINSON'S BRANCH CONFLUENCE
102 COMP	Subbasin	4.42	**Robinson's Branch Rahway River subbasin 102**
101 COMP	Subbasin	4.32	Subbasin 101
ASHBRK C	Subbasin	1.11	Ash Brook Swamp subbasin
103A COM	Subbasin	0.31	Subbasin 103 A
103B COM	Subbasin	0.17	Subbasin 103 B
ASHIN CO	Junction	10.33	Robinson's Branch inflow to Ash Brook Swamp

TABLE 2: HEC-HMS MODEL STRUCTURE (CONT.)

Element Name	Element Type	Drainage Area (mi^2)	Description
ASHOUT R	Reach	10.33	Robinson's Branch outflow from Ash Brook Swamp
Junction-7	Junction	10.33	Robinson's Branch outflow from Ash Brook Swamp
104 ROUT	Reach	10.33	Route to Pumpkin Patch Brook
103C COM	Subbasin	0.20	Subbasin 103 C
106 COMB	Junction	10.53	Robinson's Branch upstream of Pumpkin Patch Brook
107 COMP	Subbasin	2.10	Subbasin 107 : Pumpkin Patch Brook
108 COMB	Junction	12.63	Robinson's Branch downstream of Pumpkin Patch Brook
109 ROUT	Reach	12.63	Route to confluence subbasin 110
110 COMP	Subbasin	2.95	Subbasin 110
111 COMB	Junction	15.58	Robinson's Branch downstream of subbasin 110
112 ROUT	Reach	15.58	Route to confluence subbasin 113
113 COMP	Subbasin	2.63	Subbasin 113
114 COMB	Junction	18.21	Robinson's Branch downstream of subbasin 113
115 COMP	Subbasin	0.52	Subbasin 115
116 COMB	Junction	18.73	Robinson's Branch downstream of subbasin 115
117 COMP	Subbasin	1.23	Subbasin 117
118 COMB	Junction	19.96	Robinson's Branch downstream of subbasin 117
119 COMP	Subbasin	0.87	Subbasin 119
120 COMB	Junction	20.83	**Robinson's Branch downstream of subbasin 119**
121 ROUT	Reservoir	20.83	**Outflow from Middlesex Reservoir**
122 COMP	Subbasin	1.04	Subbasin 122
123 COMB	Junction	21.87	**USGS gage 01396000 Robinson's Br Rahway River at Rahway : Milton Lake Dam**
124 ROUT	Reach	21.87	Route from USGS gage Milton Lake Dam to Maple Avenue
Junction-8	Junction	21.87	
125 ROUT	Reach	21.87	Route from USGS gage Milton Lake Dam to Maple Avenue
126 COMP	Subbasin	0.20	Subbasin 126 : Milton Lake Dam to Maple Avenue
127 COMB	Junction	22.07	**USGS gage 01396000 Robinson's Branch Rahway River at Maple Ave in Rahway NJ**
128 ROUT	Reach	22.07	Route to mouth of Robinson's Branch
129 COMP	Subbasin	0.85	Subbasin 129 : Maple Avenue to mouth
130 ROBI	Junction	22.92	Robinson's Branch Rahway River at mouth
DSROBC	Junction	64.53	COMBINE UPPER RAHWAY BASIN AND ROBINSON'S BRANCH BASIN AT CONFLUENCE
UPSBR	Reach	64.53	ROUTE TO SOUTH BRANCH CONFLUENCE
RAH-O	Subbasin	0.36	COMPUTE SUBBASIN RAH-O RAHWAY MAINSTREAM - ROBINSON'S BRANCH CONFLUENCE TO SOUTH BRANCH CONFLUENCE

TABLE 2: HEC-HMS MODEL STRUCTURE (CONT.)

Element Name	Element Type	Drainage Area (mi²)	Description
UPSBC	Junction	64.89	COMBINE UPSTREAM OF SOUTH BRANCH CONFLUENCE
201	Subbasin	6.03	COMPUTE SUBBASIN ONE SOUTH BRANCH BASIN NODE 201
202	Reach	6.03	ROUTE TO NODE 202
203	Subbasin	2.91	COMPUTE SUBBASIN TWO SOUTH BRANCH BASIN NODE 203
204	Junction	8.94	COMBINE NODES 202 AND 203 TO GET NODE 204
205A	Reach	8.94	Route to New Dover Road Bridge
206A	Subbasin	0.35	Increment : to New Dover Road Bridge
Junction-New_Dover_BD	Junction	9.29	
205B	Reach	9.29	Route to upstream end Home Depot culvert
206B	Subbasin	0.69	Increment : New Dover Road Bridge to u/s end Home Depot culvert
Junction-HDCulv_US	Junction	9.98	
205C	Reach	9.98	Lag route through Home Depot culvert
206C	Subbasin	0.02	Increment : Home Depot culvert inflow
Junction-StGeor_BD	Junction	10.00	
205D	Reach	10.00	Route from St. George Avenue Bridge to mouth of South Branch
206D	Subbasin	1.81	Increment : St. George Avenue Bridge to mouth
207	Junction	11.81	COMBINE NODES 205 AND 206 TO GET NODE 207
DSSBC	Junction	76.70	COMBINE NODE 207 WITH RAHWAY MAINSTREAM
RTKGCR	Reach	76.70	ROUTE TO KINGS CREEK
RAH-P	Subbasin	3.05	COMPUTE SUBBASIN RAH-P RAHWAY MAINSTREAM
CBKGCR	Junction	79.75	COMBINE AT KINGS CREEK
RTARKL	Reach	79.75	ROUTE TO ARTHUR KILL
RAH-Q	Subbasin	3.38	COMPUTE SUBBASIN RAH-Q - RAHWAY MAINSTREAM - KINGS CREEK TO ARTHUR KILL
CBARKL	Junction	83.13	COMBINE AT ARTHUR KILL

TABLE 3(A): EXISTING CONDITIONS INPUT PARAMETERS FOR CRANFORD

Subbasin	Drainage Area (mi^2)	Percent Impervious (%)	Clark Unit Hydrograph Parameters	
			Time of Concentration Tc (hr)	Storage Coefficient R (hr)
SAA	4.61	25.40	1.00	1.63
SAB	2.46	5.30	1.12	2.07
SAC	1.12	36.90	1.00	0.94
SAD	2.62	39.80	2.40	4.44
SAE	2.21	37.20	1.94	3.60
SAF	3.28	34.10	2.31	4.29
SAG	1.94	39.60	2.54	4.72
SAH	5.47	32.90	1.72	3.19
SAI	2.84	40.50	2.41	4.48
SAK	4.32	37.40	2.90	5.37
SAJ	0.75	31.30	2.10	3.89
SAL	5.46	21.00	2.88	5.35
SAM	4.11	35.50	3.00	5.57

TABLE 3(B): EXISTING CONDITIONS INPUT PARAMETERS FOR CITY OF RAHWAY

Subbasin	Drainage Area (mi^2)	Percent Impervious (%)	Clark Unit Hydrograph Parameters	
			Time of Concentration Tc (hr)	Storage Coefficient R (hr)
SAA	4.61	25.40	1.00	1.63
SAB	2.46	5.30	1.12	2.07
SAC	1.12	36.90	1.00	0.94
SAD	2.62	39.80	2.40	4.44
SAE	2.21	37.20	1.94	3.60
SAF	3.28	34.10	2.31	4.29
SAG	1.94	39.60	2.54	4.72
SAH	5.47	32.90	1.72	3.19
SAI	2.84	40.50	2.41	4.48
SAK	4.32	37.40	2.90	5.37
SAJ	0.75	31.30	2.10	3.89
SAL	5.46	21.00	2.88	5.35
SAM	4.11	35.50	3.00	5.57
RAH-N	0.42	37.40	1.24	2.29
102 COMP	4.42	27.90	0.97	5.04
101 COMP	4.32	25.20	1.18	5.76
ASHBRK C	1.11	19.30	0.58	3.29
103A COM	0.31	12.10	0.50	2.89
103B COM	0.17	8.70	0.51	3.47
103C COM	0.20	35.00	0.55	3.63
107 COMP	2.10	34.40	0.74	4.26
110 COMP	2.95	30.00	0.75	4.30
113 COMP	2.63	32.00	0.50	3.20
115 COMP	0.52	38.60	0.66	3.98
117 COMP	1.23	41.20	0.50	3.37
119 COMP	0.87	30.20	0.50	2.84
122 COMP	1.04	28.60	0.50	3.36
126 COMP	0.20	29.60	0.50	2.47
129 COMP	0.85	40.90	0.50	3.09
RAH-O	0.36	52.60	1.40	2.60
201	6.03	37.30	3.07	5.69
203	2.91	34.60	2.95	5.46
206	2.87	35.10	4.04	7.47
RAH-P	3.05	54.40	2.91	5.38
RAH-Q	3.38	38.10	4.24	7.85

TABLE 4: EXISTING CONDITIONS REACH PARAMETERS

Reach Node	Lag Time (min)	Muskingum		
		K (hrs)	X	Number of Subreaches
AB		1.30	0.10	1
DE		0.60	0.30	1
104 ROUT		0.50	0.10	1
109 ROUT		0.41	0.10	1
112 ROUT		0.39	0.10	1
202		1.15	0.30	1
205		1.29	0.30	1
LAGAB	30			
LAGBC	30			
LAGCFG	30			

TABLE 5: INTIAL LOSS AND CONSTANT LOSS RATE (HISTORIC FLOODS)

subbasin	April 2007		TC Irene (August 2011)	
	initial loss (in)	constant rate (in/hr)	initial loss (in)	constant rate (in/hr)
SAA	1.00	0.1300	1.00	0.0760
SAB	1.00	0.1300	1.00	0.0760
SAC	1.00	0.1300	1.00	0.0760
SAD	1.00	0.1300	1.00	0.0760
SAE	1.00	0.1300	1.00	0.0760
SAF	1.00	0.1300	1.00	0.0760
SAG	1.00	0.1300	1.00	0.0760
SAH	1.00	0.1300	1.00	0.0760
SAI	1.00	0.1300	1.00	0.0760
SAK	1.00	0.0685	1.00	0.0420
SAJ	1.00	0.0685	1.00	0.0420
SAL	1.00	0.0685	1.00	0.0420
SAM	1.00	0.0685	1.00	0.0420
RAH-N	0.50	0.0170	0.50	0.0100
102 COMP	0.50	0.0170	1.50	0.0050
101 COMP	0.50	0.0170	1.50	0.0050
ASHBRK C	0.50	0.0170	1.50	0.0050
103A COM	0.50	0.0170	1.50	0.0050
103B COM	0.50	0.0170	1.50	0.0050
103C COM	0.50	0.0170	1.50	0.0050

Table 5: Initial Loss and Constant Loss Rate (Historical Floods)(Cont.)

subbasin	April 2007		TC Irene (August 2011)	
	initial loss (in)	constant rate (in/hr)	initial loss (in)	constant rate (in/hr)
107 COMP	0.50	0.017	1.50	0.005
110 COMP	0.50	0.017	1.50	0.005
113 COMP	0.50	0.017	1.50	0.005
115 COMP	0.50	0.017	1.50	0.005
117 COMP	0.50	0.017	1.50	0.005
119 COMP	0.50	0.017	1.50	0.005
122 COMP	0.50	0.017	1.50	0.005
126 COMP	0.50	0.017	1.50	0.005
129 COMP	0.50	0.017	1.50	0.005
RAH-O	0.50	0.017	0.50	0.010
201	0.50	0.017	0.50	0.010
203	0.50	0.017	0.50	0.010
206	0.50	0.017	0.50	0.010
RAH-Q	0.50	0.017	0.50	0.010

TABLE 6: CITY OF RAHWAY: HISTORICAL FLOODS – PEAK DISCHARGES

Node Name	Drainage Area (mi2)	Historical Event	
		April 2007	August 2011
WESTBR	8.19	1680	2920
EASTBR	8.11	1730	2820
EWCONF	16.30	3380	5710
SPRDSI	26.55	4720	8620
DSK	30.87	5520	10030
JCT-4	31.62	5030	10140
JCT-5	31.62	4330	8510
DSL	37.08	4790	7000
RAHDSM	41.19	4910	7250
UPROBC	41.61	4910	7230
120	20.83	3330	5080
123	21.87	3540	5370
127	22.07	3520	5380
130	22.92	3480	5230
DSROBC	64.53	7110	12130
UPSBR	64.53	7100	12120
HDCULV_US	9.98	2280	3000
207	11.81	2580	3410
DSSBC	76.70	9290	15430

TABLE 7(A): ANNUAL PEAK FLOWS – USGS GAGE #1394500 RAHWAY RIVER NEAR SRRINGFIELD, NJ (BASED UPON COE RATING FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
1938	23 Jul 1938	2050	2825
1939	03 Feb 1939	699	699
1940	31 May 1940	1140	1290
1941	07 Feb 1941	885	930
1942	09 Aug 1942	1320	1600
1943	30 Dec 1942	663	663
1944	13 Mar 1944	815	850
1945	19 Sep 1945	1370	1690
1946	02 Jun 1946	975	1045
1947	05 Apr 1947	646	646
1948	08 Nov 1947	1280	1510
1949	06 Jan 1949	834	865
1950	23 Mar 1950	501	501
1951	30 Mar 1951	954	1020
1952	01 Jun 1952	1280	1510
1953	13 Mar 1953	1330	1635
1954	11 Sep 1954	947	1000
1955	13 Aug 1955	1270	1500
1956	14 Oct 1955	643	643
1957	05 Apr 1957	538	538
1958	28 Feb 1958	844	870
1959	09 Aug 1959	885	930
1960	12 Sep 1960	911	960
1961	16 Apr 1961	708	715
1962	12 Mar 1962	1530	2035
1963	06 Mar 1963	675	680
1964	07 Nov 1963	748	760
1965	08 Feb 1965	838	870
1966	22 Sep 1966	1520	2020
1967	07 Mar 1967	1170	1330
1968	29 May 1968	3370	4330
1969	29 Jul 1969	1510	2000
1970	31 Jul 1970	1170	1330

TABLE 7(B): ANNUAL PEAK FLOWS – USGS GAGE #1394500 RAHWAY RIVER NEAR SRRINGFIELD, NJ (BASED UPON COE RATING FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
1971	28 Aug 1971	3430	4390
1972	22 Jun 1972	1160	1390
1973	02 Aug 1973	5430	6130
1974	21 Dec 1973	1870	2590
1975	14 Jul 1975	3110	1400
1976	10 Aug 1976	960	1010
1977	22 Mar 1977	1950	2700
1978	08 Nov 1977	2180	2980
1979	24 Jan 1979	1540	2060
1980	21 Mar 1980	1250	1550
1981	11 May 1981	926	1000
1982	04 Jan 1982	1650	2240
1983	10 Apr 1983	1360	1730
1984	05 Apr 1984	1660	2250
1985	27 Sep 1985	1410	1830
1986	17 Nov 1985	1210	1480
1987	14 Jul 1987	1290	1620
1988	26 Jul 1988	1170	1330
1989	19 Sep 1989	1590	2130
1990	20 Oct 1989	936	1020
1991	04 Mar 1991	1400	1810
1992	05 Jun 1992	3460	4590
1993	01 Apr 1993	1300	1630
1994	28 Jan 1994	1520	2030
1995	18 Jul 1995	1150	1370
1996	19 Jan 1996	1530	2030
1997	25 Jul 1997	5150	5900
1998	02 Apr 1998	1400	1810
1999	16 Sep 1999	7990	7990
2000	18 May 2000	768	768
2001	17 Dec 2000	1170	1330
2002	18 May 2002	824	850
2003	21 Jun 2003	1150	1370

TABLE 7(C): ANNUAL PEAK FLOWS – USGS GAGE #1394500 RAHWAY RIVER NEAR SRRINGFIELD, NJ (BASED UPON COE RATING FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
2004	27 Jul 2004	1460	1900
2005	28 Mar 2005	1370	1770
2006	08 Oct 2005	1520	2030
2007	15 Apr 2007	4690	5540
2008	06 Sep 2008	1900	2610
2009	12 Dec 2008	1370	1690
2010	**13 Mar 2010**	**2600**	**3530**
2011	**28 Aug 2011**	**8620**	**8860**
2012	**08 Dec 2011**	**1480**	**1480**
2013	**08 Jun 2013**	**3310**	**3310**

Note: Red bold font indicated the recorded data used to develop discharge vs. frequency curve up to WY2013.

TABLE 8(A): ANNUAL PEAK FLOWS – USGS GAGE #1395000 RAHWAY RIVER AT RAHWAY, NJ (BASED UPON PRE TO POST LENAPE PARK RELATION FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
1922	19 May 1922	642	540
1923	17 Mar 1923	811	680
1924	07 Apr 1924	1350	1150
1925	12 Feb 1925	1000	830
1926	07 Sep 1926	984	810
1927	02 Aug 1927	1740	1250
1928	06 Jul 1928	1310	1,100
1929	27 Feb 1929	755	630
1930	08 Mar 1930	569	450
1931	29 Mar 1931	500	400
1932	28 Mar 1932	905	750
1933	16 Sep 1933	1560	1300
1934	05 Mar 1934	722	580
1935	06 Oct 1934	660	550
1936	12 Mar 1936	1120	950
1937	20 Dec 1936	640	539
1938	24 Jul 1938	3140	2650
1939	03 Feb 1939	847	700
1940	31 May 1940	1560	1300
1941	07 Feb 1941	976	800
1942	09 Aug 1942	1440	1200
1943	30 Dec 1942	847	700
1944	14 Sep 1944	1340	1120
1945	19 Sep 1945	1570	1310
1946	23 Jul 1946	1140	955
1947	05 Apr 1947	622	520
1948	09 Nov 1947	1350	1150
1949	31 Dec 1948	1350	1150
1950	23 Mar 1950	510	410
1951	31 Mar 1951	1020	840
1952	01 Jun 1952	1720	1430
1953	13 Mar 1953	1590	1350
1954	11 Sep 1954	1380	1160

TABLE 8(B): ANNUAL PEAK FLOWS – USGS GAGE #1395000 RAHWAY RIVER AT RAHWAY, NJ (BASED UPON PRE TO POST LENAPE PARK RELATION FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
1955	13 Aug 1955	2440	2030
1956	08 Apr 1956	600	500
1957	06 Apr 1957	770	638
1958	28 Feb 1958	1170	960
1959	09 Aug 1959	1580	1330
1960	12 Sep 1960	1850	1550
1961	23 Mar 1961	878	730
1962	13 Mar 1962	1740	1250
1963	06 Mar 1963	770	638
1964	07 Nov 1963	1210	1000
1965	08 Feb 1965	1130	930
1966	21 Sep 1966	1940	1600
1967	07 Mar 1967	1670	1400
1968	29 May 1968	3530	3030
1969	04 Sep 1969	1830	1540
1970	31 Jul 1970	1720	1430
1971	28 Aug 1971	4010	3540
1972	13 Jul 1972	1140	955
1973	02 Aug 1973	5420	5030
1974	21 Dec 1973	2640	2250
1975	15 Jul 1975	5070	4670
1976	28 Jan 1976	1140	955
1977	23 Mar 1977	2430	2040
1978	08 Nov 1977	3570	3100
1979	24 Jan 1979	2680	2250
1980	28 Apr 1980	1860	1860
1981	12 May 1981	708	708
1982	04 Jan 1982	1820	1820
1983	10 Apr 1983	2090	2090
1984	14 Dec 1983	2880	2880
1985	27 Sep 1985	1700	1700
1986	17 Apr 1986	1710	1710
1987	04 Apr 1987	1280	1280

TABLE 8(C): ANNUAL PEAK FLOWS – USGS GAGE #1395000 RAHWAY RIVER AT RAHWAY, NJ (BASED UPON PRE TO POST LENAPE PARK RELATION FROM 1984 SPRINGFIELD, NJ HYDROLOGY APPENDIX)

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)	
		Recorded	Adjusted
1988	22 Jul 1988	1130	1130
1989	20 Sep 1989	2150	2150
1990	20 Oct 1989	1260	1260
1991	04 Mar 1991	1480	1480
1992	05 Jun 1992	2890	2890
1993	01 Apr 1993	1140	1140
1994	10 Mar 1994	1580	1580
1995	18 Jul 1995	1360	1360
1996	19 Jan 1996	1790	1790
1997	19 Oct 1996	4210	4210
1998	23 Jan 1998	1440	1440
1999	17 Sep 1999	5590	5590
2000	27 Aug 2000	1130	1130
2001	30 Mar 2001	1460	1460
2002	18 May 2002	706	706
2003	05 Jun 2003	1920	1920
2004	28 Jul 2004	1440	1440
2005	28 Mar 2005	1500	1500
2006	09 Oct 2005	1710	1710
2007	16 Apr 2007	4910	4910
2008	07 Sep 2008	1530	1530
2009	12 Dec 2008	1550	1550
2010	**14 Mar 2010**	**3690**	**3690**
2011	**28 Aug 2011**	**7250**	**7250**
2012	**08 Dec 2011**	**1390**	**1390**
2013	**08 Jun 2013**	**1350**	**1350**

Note: Red bold font indicated the recorded data used to develop discharge vs. frequency curve up to WY2013.

TABLE 9 (A): ANNUAL PEAK FLOWS - USGS GAGE #01396000 ROBINSONS BRANCH AT RAHWAY NJ

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)
1940	31 May 1940	2856
1941	7 Feb 1941	1669
1942	9 Aug 1942	2394
1943	12 May 1943	1275
1944	6 Jan 1944	1525
1945	19 Sep 1945	1798
1946	2 Jun 1946	1631
1947	5 Apr 1947	916
1948	8 Nov 1947	1806
1949	31 Dec 1948	1472
1950	23 Mar 1950	812
1951	30 Mar 1951	1220
1952	1 Jun 1952	1951
1953	13 Mar 1953	2193
1954	14 Dec 1953	559
1955	13 Aug 1955	1384
1956	8 Apr 1956	701
1957	5 Apr 1957	739
1958	28 Feb 1958	1438
1959	9 Aug1959	1349
1960	12 Sep 1960	1446
1961	23 Mar 1961	1039
1962	12 Mar 1962	1309
1963	6 Mar 1963	720
1964	7 Nov 1963	747
1965	8 Feb 1965	657
1966	21 Sep 1966	1071
1967	7 Mar 1967	1430
1968	29 May 1968	2550
1969	15 Aug 1969	2590
1970	31 Jul 1970	1070
1971	27 Aug 1971	2550
1972	13 Jul 1972	1080
1973	2 Aug 1973	2380
1974	21 Dec 1973	1280
1975	15 Jul 1975	3110
1976	12 Nov 1975	868

TABLE 9 (B): ANNUAL PEAK FLOWS - USGS GAGE #01396000 ROBINSONS BRANCH AT RAHWAY NJ

Water Year	Annual Peak Flow Date	Annual Peak Flows (cfs)
1977	22 Mar 1977	1200
1978	8 Nov 1977	1820
1979	23 May 1979	1470
1980	28 Apr 1980	1290
1981	11 May 1981	561
1982	4 Jan 1982	1200
1983	10 Apr 1983	1330
1984	14 Dec 1983	1500
1985	27 Sep 1985	1260
1986	17 Nov 1985	1140
1987	4 Apr 1987	1110
1988	22 Jul 1988	1450
1989	20 Sep 1989	2980
1990	10 Aug 1990	1330
1991	4 Mar 1991	1340
1992	5 Jun 1992	2280
1993	1 Apr 1993	754
1994	28 Jan 1994	1430
1995	18 Jul 1995	850
1996	19 Jan 1996	1650
1999	16 Sep 1999	4800
2000	27 Jul 2000	No data
2001	30 Mar 2001	1080
2002	18 May 2002	424
2003	4 Jun 2003	1510
2004	12 May 2004	1400
2005	28 Mar 2005	1230
2006	8 Oct 2005	1050
2007	15 Apr 2007	3630
2008	6 Sep 2008	2050
2009	12 Dec 2008	1110
2010	13 Mar 2010	4080
2011	28 Aug 2011	5600
2012	08 Dec 2011	1250
2013	07 Jun 2013	2980

TABLE 10(A): CRANFORD - INITIAL LOSS AND CONSTANT LOSS RATE – (HYPOTHETICAL FLOODS)

Subbasin	Initial Loss (in)	Constant Loss Rate (in/hr)								
		1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
SAA	1.00	0.2670	0.2575	0.31895	0.2636	0.2140	0.1971	0.1764	0.14631	0.1070
SAB	1.00	0.2670	0.2575	0.31895	0.2636	0.2140	0.1971	0.1764	0.14631	0.1070
SAC	1.00	0.2670	0.2575	0.31895	0.2636	0.2140	0.1971	0.1764	0.14631	0.1070
SAD	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAE	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAF	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAG	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAH	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAI	1.00	0.4000	0.3700	0.4279	0.3500	0.2500	0.2330	0.1910	0.1590	0.1130
SAK	1.00	0.4000	0.3700	0.3390	0.2200	0.2500	0.2330	0.1910	0.1590	0.1130
SAJ	1.00	0.4000	0.3700	0.3390	0.2200	0.2500	0.2330	0.1910	0.1590	0.1130
SAL	1.00	0.4000	0.3700	0.3390	0.2200	0.2500	0.2330	0.1910	0.1590	0.1130
SAM	1.00	0.4000	0.3700	0.3390	0.2200	0.2500	0.2330	0.1910	0.1590	0.1130

TABLE 10(B): CITY OF RAHWAY - INITIAL LOSS AND CONSTANT LOSS RATE – (HYPOTHETICAL FLOODS)

Subbasin	Initial Loss (in)	Constant Loss Rate (in/hr)								
		1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
SAA	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAB	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAC	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAD	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAE	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAF	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAG	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAH	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAI	1.00	0.2900	0.2750	0.3250	0.2560	0.2010	0.1750	0.1502	0.1117	0.0687
SAK	1.00	0.6000	0.4000	0.0500	0.0290	0.0254	0.0356	0.0500	0.1146	0.1115
SAJ	1.00	0.6000	0.4000	0.0500	0.0290	0.0254	0.0356	0.0500	0.1146	0.1115
SAL	1.00	0.6000	0.4000	0.0500	0.0290	0.0254	0.0356	0.0500	0.1146	0.1115
SAM	1.00	0.6000	0.4000	0.0500	0.0290	0.0254	0.0356	0.0500	0.1146	0.1115
RAH-N	1.00	0.6000	0.4000	0.0500	0.0290	0.0254	0.0356	0.0500	0.1146	0.1115
102 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
101 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
ASHBRK C	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
103A COM	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
103B COM	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
103C COM	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
107 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
110 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703

TABLE 10(B): CITY OF RAHWAY - INITIAL LOSS AND CONSTANT LOSS RATE – (HYPOTHETICAL FLOODS; CONT.)

Subbasin	Initial Loss (in)	Constant Loss Rate (in/hr)								
		1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
113 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
115 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
117 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
119 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
122 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
126 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
129 COMP	1.00	0.2120	0.2430	0.2280	0.2040	0.1800	0.1630	0.1349	0.1127	0.0703
RAH-O	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
201	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
203	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
206A	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
206B	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
206C	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
206D	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
RAH-P	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
RAH-Q	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850
RAH-Q	1.00	0.3365	0.2993	0.2283	0.1869	0.1549	0.1411	0.1244	0.1155	0.0850

TABLE 11: EXISTING CONDITIONS - PEAK DISCHARGES (CFS) FOR CRANFORD

HMS Node	D.A. (mi^2)	Return Period (discharge is in cfs)									
		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr	April 07
WESTBR	8.19	460	670	910	1280	2020	2740	3490	4180	5190	1680
EASTBR	8.11	630	820	1060	1360	1910	2330	2820	3340	4130	1730
EWCONF	16.30	1060	1450	1930	2580	3880	5050	6300	7520	9310	3380
SPRDSI	26.55	1500	2000	2660	3460	4950	6300	7910	9820	12870	4720
DSK	30.87	1780	2340	3130	4130	5700	7260	9090	11290	14720	5520
JCT-4	31.62	1360	1660	2080	2790	4400	6360	8680	11190	14870	5030
JCT-5	31.62	1300	1590	1950	2510	3610	4880	6620	8510	11430	4330
DSL	37.08	1310	1620	1990	2560	3590	4740	6310	8070	10700	4790
RAHDSM	41.19	1270	1570	1960	2490	3460	4480	5830	7520	10160	4910

TABLE 12: EXISTING CONDITIOSN – PEAK DISCHARGES (CFS) FOR CITY OF RAHWAY

HMS NODE	Drainage Area (mi^2)	Return Period (discharge is in cfs)									
		1yr	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr	Irene
WESTBR	8.19	440	650	910	1310	2090	2870	3630	4350	5360	2920
EASTBR	8.11	680	880	1140	1480	2020	2470	2940	3500	4270	2820
EWCONF	16.30	1100	1490	2000	2730	4070	5320	6570	7840	9620	5710
SPRDSI	26.55	1580	2100	2800	3690	5250	6700	8370	10340	13450	8620
DSK	30.87	1840	2450	3540	4610	6320	7940	9780	11890	15320	10030
JCT-4	31.62	1390	1710	2340	3230	5340	7250	9580	11870	15480	10140
JCT-5	31.62	1320	1630	2160	2830	4180	5690	7300	9160	11960	8510
DSL	37.08	1300	1650	2260	2970	4270	5600	7100	8660	11150	7000
RAHDSM	41.19	1220	1610	2250	2950	4150	5300	6620	8160	10600	7250
UPROBC	41.61	1220	1610	2260	2960	4150	5300	6610	8130	10580	7230
120	20.83	1290	1590	2180	2730	3510	4190	4950	5760	6990	5080
123	21.87	1200	1510	2120	2720	3600	4330	5150	6050	7390	5370
127	22.07	1210	1510	2120	2700	3560	4290	5140	6090	7460	5380
130	22.92	1260	1550	2130	2700	3510	4300	5020	5810	7320	5230
DSROBC	64.53	1760	2270	3500	4450	5770	6900	8130	9520	12540	12130
UPSBR	64.53	1760	2270	3500	4450	5750	6890	8110	9520	12530	12120
HDCULV_US	9.98	720	950	1370	1770	2350	280	3330	3860	4690	2990
207	11.81	810	1060	1530	1990	2660	3210	3800	4420	5400	3410
DSSBC	76.70	2520	3330	5060	6490	8490	10180	11950	13650	16880	15430

TABLE 13: PERECENT IMPERVIOUS AREAS AS A FUNCTION OF LOT SIZE

Average Lot Size (Acres)	Average Percent Impervious Area
0.125	65
0.250	38
0.333	30
0.500	25
1.000	20
2.000	12

TABLE 14: FUTURE UNIMPROVED CALCULATIONS

Subbasin Node	Drainage Area (mi^2)	Percent Imprevious (%)	Time of Concentration (hr)	Storage Coefficient (hr)
SAA	4.61	29.90	0.91	1.48
SAB	2.46	5.30	1.12	2.07
SAC	1.12	36.90	1.00	0.94
SAD	2.62	40.10	2.39	4.42
SAE	2.21	37.60	1.93	3.57
SAF	3.28	36.70	2.20	4.09
SAG	1.94	39.60	2.54	4.72
SAH	5.47	34.50	1.67	3.09
SAI	2.84	47.90	2.13	3.96
SAK	4.32	39.00	2.82	5.22
SAJ	0.75	36.50	1.90	3.52
SAL	5.46	21.10	2.87	5.34
SAM	4.11	35.60	2.99	5.56
RAH-N	0.42	37.40	1.24	2.29
102 COMP	4.42	29.34	0.94	4.89
101 COMP	4.32	26.14	1.16	5.64
ASHBRK C	1.11	19.30	0.58	3.29
103A COM	0.31	24.50	0.37	2.12
103B COM	0.17	27.06	0.32	2.18
103C COM	0.20	35.00	0.55	3.63
107 COMP	2.10	35.89	0.72	4.14

TABLE 14: FUTURE UNIMPROVED CALCULATIONS (CONT.)

Subbasin Node	Drainage Area (mi^2)	Percent Imprevious (%)	Time of Concentration (hr)	Storage Coefficient (hr)
110 COMP	2.95	32.15	0.72	4.12
113 COMP	2.63	32.00	0.50	3.20
115 COMP	0.52	38.60	0.66	3.98
117 COMP	1.23	46.16	0.46	3.10
119 COMP	0.87	30.20	0.50	2.84
122 COMP	1.04	28.60	0.50	3.36
126 COMP	0.20	29.60	0.50	2.47
129 COMP	0.85	40.90	0.50	3.09
RAH-O	0.36	52.60	1.40	2.60
201	6.03	38.12	3.02	5.61
203	2.91	34.94	2.93	5.43
206A	0.35	27.61	0.81	1.49
206B	0.69	39.22	0.82	1.52
206C	0.02	72.00	0.17	0.31
206D	1.81	36.80	1.42	2.62
RAH-P	3.05	54.40	2.91	5.38
RAH-Q	3.38	38.10	4.24	7.85

TABLE 15: FUTURE UNIMPROVED CONDITIONS - PEAK DISCHARGES (CFS) FOR CRANFORD

HMS NODE	Drainage Area (mi^2)	Return Period (discharge is in cfs)								
		1yr	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
WESTBR	8.19	510	730	990	1370	2160	2900	3650	4320	5330
EASTBR	8.11	650	840	1080	1380	1940	2360	2850	3380	4170
EWCONF	16.30	1120	1530	2030	2700	4060	5240	6500	7690	9490
SPRDSI	26.55	1560	2080	2770	3570	5100	6440	8110	9980	13070
DSK	30.87	1860	2430	3250	4250	5870	7430	9320	11480	14960
JCT-4	31.62	1400	1710	2150	2890	4590	6550	8930	11390	15110
JCT-5	31.62	1340	1630	2010	2590	3730	5030	6770	8660	11580
DSL	37.08	1360	1660	2050	2630	3700	4870	6450	8190	10820
RAHDSM	41.19	1310	1620	2010	2570	3550	4590	5950	7650	10280

TABLE 16: FUTURE UNIMPROVED CONDITIONS - PEAK DISCHARGES (CFS) FOR CITY OF RAHWAY

HMS NODE	Drainage Area (mi^2)	Return Period (discharge is in cfs)								
		1yr	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
WESTBR	8.19	490	710	980	1400	2230	3020	3780	4480	5490
EASTBR	8.11	700	900	1160	1510	2050	2500	2970	3530	4300
EWCONF	16.30	1150	1570	2100	2850	4250	5510	6750	8000	9790
SPRDSI	26.55	1640	2180	2910	3800	5400	6860	8550	10480	13630
DSK	30.87	1910	2540	3650	4720	6480	8110	9980	12060	15530
JCT-4	31.62	1430	1750	2420	3340	5530	7400	9790	12050	15690
JCT-5	31.62	1360	1670	2220	2900	4290	5820	7430	9290	12090
DSL	37.08	1340	1700	2320	3040	4370	5720	7230	8770	11270
RAHDSM	41.19	1260	1650	2310	3020	4240	5400	6740	8270	10700
UPROBC	41.61	1260	1650	2310	3020	4250	5400	6730	8240	10680
120	20.83	1330	1640	2240	2800	3590	4280	5050	5870	7110
123	21.87	1240	1560	2180	2780	3680	4410	5250	6150	7500
127	22.07	1240	1560	2170	2760	3630	4370	5240	6190	7570
130	22.92	1300	1590	2180	2750	3580	4360	5080	5900	7410
DSROBC	64.53	1810	2330	3570	4530	5860	7010	8230	9640	12650
UPSBR	64.53	1810	2330	3570	4530	5840	6990	8220	9630	12650
HDCULV_US	9.98	730	960	1380	1790	2370	2830	3350	3880	4710
207	11.81	820	1080	1550	2010	2680	3230	3830	4450	5430
DSSBC	76.70	2580	3400	5150	6590	8600	10300	12080	13790	17030

TABLE 17: DESCRIPTION OF ALTERNATIVES UNDER IMPROVED CONDITIONS

Name of Alternative	Project Area	Description
Alternative #1	Cranford	Lenape Park Detention Basin and Channel Modifications
Alternative #2	Cranford	Lenape Park Detention Basin and Nomahegan Park Levee Modifications and Channel Modifications
Alternative #3	Cranford/Milburn	Channel Modification and Orange Reservoir
Alternative #4	Cranford/Milburn	Channel Modification and Orange Reservoir Outlet Modification
Alternative #4a	Cranford/Milburn	Small Channel Modification and Orange Reservoir Outlet Modification w/Replacement
Alternative #5	Cranford/Milburn	Channel Modification with South Mountain Reservoir (dry detention)
Alternative #6	Cranford/Milburn	South Mountain Detention Basin
Alternative #8	Cranford/Milburn	Lenape Park Detention Basin and Orange Reservoir Outlet Modifications
Alternative #9	Cranford/Milburn	Lenape Park Detention Basin, Orange Reservoir Outlet Modifications and Small Channel Modifications
Alternative #1	City of Rahway	Levees, Floodwalls and Channel Modifications
Alternative #3	City of Rahway	Modification of Middlesex Reservoir

TABLE 18 (A): ORANGE RESERVOIR STORAGE-ELEVATION-DISCHARGE DATA

Elevation (NAVD88)	Storage (acre-ft)	Dicharge (cfs)
296.00	0.00	0.00
300.00	3.00	0.01
310.00	86.00	0.02
320.00	320.00	0.03
330.00	720.00	0.04
331.20	736.00	0.05
332.00	836.00	164.86
334.00	970.00	1079.49
334.50	1006.00	1381.19
336.00	1123.00	7035.95
338.00	1296.00	20527.28
339.00	1388.00	28988.94

TABLE 18 (B): SOUTH MOUNTAIN STORAGE-ELEVATION-DISCHARGE DATA

Elevation (ft., NAVD 88)	Storage (acre-ft)	Discharge (cfs)
170.00	0.00	0.00
170.50	0.11	10.66
171.00	0.43	19.64
171.30	0.73	21.18
171.50	0.97	20.63
172.00	1.72	27.24
175.00	10.74	43.07
180.00	43.45	60.91
185.00	99.19	74.59
190.00	174.55	86.13
195.00	263.80	96.30
200.00	364.36	105.49
205.00	504.25	113.94
210.00	693.78	121.81
215.00	914.12	129.20
220.00	1170.01	136.19
225.00	1466.85	142.84
230.00	1809.49	149.19
235.00	2206.21	155.28
236.00	2292.55	1396.47
237.00	2381.31	3664.90
238.00	2472.49	6602.05
239.00	2566.09	10079.98
240.00	2662.10	14024.76
241.00	2760.54	18386.49
242.00	2861.41	23128.55
243.00	2964.72	28222.55
244.00	3070.45	33645.68
245.00	3178.62	39379.04
246.00	3289.34	45406.67
247.00	3402.70	53078.84
248.00	3518.70	62149.56
249.00	3637.36	72213.91
250.00	3758.66	83121.76
250.00	3758.66	83121.76

TABLE 19: ORANGE RESERVOIR ALTERNATIVES – PEAK DISCHARGES (CFS) FOR CRANFORD

HMS NODE	Drainage Area (mi^2)	Existing Conditions					With Outlet Modification (Alt #3, 4, 4(a), #8)				
		1yr	10yr	50yr	100yr	500yr	1yr	10yr	50yr	100yr	500yr
Orange_Res (I)	4.61	940	1940	2930	3410	4510	940	1940	2930	3410	4510
Orange_Res (O)	4.61	390	1080	2540	3140	4370	0	110	1090	1950	4200
Dia_Mill_Pond (O)	7.07	440	1260	2700	3380	5150	340	790	1350	2160	4570
WESTBR	8.19	460	1280	2740	3490	5190	350	830	1420	2210	4620
EWCONF	16.30	1060	2580	5050	6300	9310	970	2170	3710	4840	8700
SPRDSI	26.55	1500	3460	6300	7910	12870	1440	3230	5550	7030	11970

TABLE 20: SOUTH MOUNTAIN DRY DETENION ALTERNATIVES – PEAK DISCHARGES (CFS) FOR CRANFORD

HMS Node	Drainage Area (mi2)	Alt #5, #5(a), #6, $6(a)				
		1-yr	10-yr	50-yr	100-yr	500-yr
Orange_Res (I)	4.61	940	1940	2930	3410	4510
Orange_Res (O)	4.61	390	1080	2540	3140	4370
Junction-1 (SM (I))	7.07	440	1260	2700	3390	5160
SM (O)	7.07	90	120	140	150	2230
WESTBR	8.19	360	700	1010	1160	2120
EWCONF	16.30	760	1600	2710	3260	5110
SPRDSI	26.55	1380	2970	5060	6110	9400

TABLE 21: CLARK UNIT HYDROGRAPHS PEAKED UP TO 25% FOR PMF

Element Name	Drainage Area (mi2)	Modified Clark UH:		Modified (5 min) Unitgraph Peak (cfs)
		Tc (hr)	R (hr)	
SAA	4.61	0.728	1.184	1857
SAB	2.46	0.896	1.656	735
SAC	1.12	0.800	0.752	599
SAD	2.62	1.912	3.536	369
SAE	2.21	1.544	2.856	386
SAF	3.28	1.760	3.270	501
SAG	1.94	2.032	3.776	257
SAH	5.47	1.336	2.472	1102
SAI	2.84	1.704	3.168	448
SAK	4.32	2.256	4.176	516
SAJ	0.75	1.520	2.816	133
SAL	5.46	2.296	4.272	639
SAM	4.11	2.392	4.448	462
RAH-N	0.42	0.992	1.832	114
102 COMP	4.42	0.773	4.022	639
101 COMP	4.32	0.944	4.608	543
ASHBRK C	1.11	NONE	NONE	8528.2
103A COM	0.31	0.302	2.312	79
103B COM	0.17	0.408	2.776	36
103C COM	0.20	0.440	2.904	41
107 COMP	2.10	0.592	3.408	361
110 COMP	2.95	0.600	3.440	502
113 COMP	2.63	0.358	2.560	605
115 COMP	0.52	0.528	3.184	96
117 COMP	1.23	0.392	2.696	267
119 COMP	0.87	0.292	2.272	224
122 COMP	1.04	0.388	2.688	226
126 COMP	0.20	0.219	1.976	60
129 COMP	0.85	0.336	2.472	204
RAH-O	0.36	1.120	2.080	86
201	6.03	2.456	4.552	662
203	2.91	2.360	4.368	333
206A	0.35	0.752	1.384	125

TABLE 21: CLARK UNIT HYDROGRAPHS PEAKED 25% FOR PMF (CONT.)

Element Name	Drainage Area (mi2)	Modified Clark UH:		Modified (5 min) Unitgraph Peak (cfs)
		Tc (hr)	R (hr)	
206B	0.69	0.688	1.272	267
206C	0.02	0.125	0.227	36
206D	1.81	1.136	2.096	428
RAH-P	3.05	2.328	4.304	354
RAH-Q	3.38	3.390	6.280	269

TABLE 22: PMP DEPTH IN INCHES (HMR 52 INPUT)

Area (mi^2)	PMP Durations				
	6 hrs	12 hrs	24 hrs	48 hrs	72 hrs
10	26.25	29.90	33.50	37.25	38.75
200	18.00	21.65	25.15	28.50	29.55
1000	13.00	16.30	20.00	23.35	24.00
5000	7.95	11.30	14.00	17.50	18.60
10000	6.05	9.25	11.75	14.94	15.90
20000	4.40	7.35	9.75	13.00	13.85

TABLE 23: PMS SUB-WATERSHED AVERAGE PMS

Description	Centroid of PMS Ellipsoid Information				
	Orange Reservoir	Lenape Park Detention Basin	Middlesex Reservoir	Rahway River u/s Robinson Branch*	Rahway at Mouth*
Optimized Storm Orientation in Degrees	210	213	187	200	190
Optimized Storm Area (mi^2)	10.00	50.00	25.00	50.00	100.00
Drainage Area (mi^2)	4.61	31.70	21.00	44.10	89.60
Total PMS in inches	38.95	35.45	36.03	33.93	31.52

* - Note: These locations are not dams, however it was used for optimizing PMS and PMF.

TABLE 24: SUBBASIN TOTAL PMS DEPTHS FOR SIX PMS CENTERINGS WITH OPTIMIZATION

Subbasin	Total PMS in Inches					
	Orange Reservoir	Lenape Park Detention Basin	Middlesex Reservoir	Rahway River u/s Robinson Branch*	Rahway River at Mouth*	"Four Centering"
SAA	38.95	34.39	14.22			38.95
SAA	38.95	34.39	14.22			38.95
SAB	34.04	36.60	17.68			36.60
SAC	26.19	36.50	21.08			36.50
SAD	31.48	34.76	13.32			34.76
SAE	26.23	35.62	14.33			35.62
SAF	23.67	36.40	17.27			36.40
SAG	18.11	36.13	19.87			36.13
SAH	19.34	35.82	23.52			35.82
SAI	16.18	35.41	25.15			35.41
SAK	15.28	34.54	32.31			34.54
SAJ	14.15	33.33	22.85			33.33
SAL	13.09	31.07	30.58	34.86	35.01	34.45
SAM	10.25	20.94	21.63	28.16	34.13	32.17
RAH-N	8.13	17.68	17.72	21.55	31.71	31.71
102 COMP	10.61	25.34	35.32			35.32
101 COMP	8.13	20.16	36.92			36.92
ASHBRK C	10.05	21.43	37.44			37.44
103A COM	10.13	22.99	37.44			37.44
107 COMP	9.03	19.24	36.00			36.00
110 COMP	12.05	28.69	36.83			36.83
113 COMP	12.15	29.57	37.09			37.09
115 COMP	10.13	21.55	36.17			36.17
117 COMP	10.61	24.11	32.85			32.85

* - Note: These locations are not dams, however it was used for optimizing PMS and PMF.

TABLE 24: SUBBASIN TOTAL PMS DEPTHS FOR SIX PMS CENTERINGS WITH OPTIMIZATION (CONT.)

Subbasin		Total PMS in Inches					
		Orange Reservoir	Lenape Park Detention Basin	Middlesex Reservoir	Rahway River u/s Robinson Branch	Rahway River at Mouth	"Four Centering"
119 COMP		10.04	21.07	30.44			32.90
122 COMP		8.91	18.61	28.03	25.02	33.94	32.56
126 COMP		8.13	17.68	21.95	21.58	33.09	31.52
129 COMP		8.13	17.68	20.62	21.75	32.61	31.40
RAH-O		7.91	15.68	17.72	19.55	30.81	30.81
201		7.07	15.58	29.61	19.37	30.99	30.99
203		7.34	16.18	25.62	20.19	32.06	32.06
206A		0.35	7.35	15.80	20.61	19.70	31.55
206B		0.69	7.35	15.80	20.61	19.70	31.55
206C		0.02	7.35	15.80	20.61	19.70	31.55
206D		1.81	7.35	15.80	20.61	19.70	31.55
RAH-P		3.05	7.00	15.24	15.68	18.45	28.72
RAH-Q		3.38	5.70	12.62	12.52	14.91	21.82

TABLE 25: PMS DEPTH FOR FREQUENCY STORM DURATIONS

Duration	PMP Depths in Inches				
	Orange Reservoir	Lenape Park Detention Basin	Middlesex Reservoir	Rahway River u/s of Robinson Branch	Rahway River at Mouth
5 minutes	1.72	1.72	1.72	1.72	1.72
15 minutes	4.67	4.67	4.67	4.67	4.67
1 hour	14.39	14.39	14.39	14.39	14.39
2 hours	18.50	18.50	18.50	18.50	18.50
3 hours	21.04	21.04	21.04	21.04	21.04
6 hours	26.30	26.30	26.30	26.30	26.30
12 hours	29.90	29.90	29.90	29.90	29.90
24 hours	33.50	33.50	33.50	33.50	33.50
48 hours	37.15	37.15	37.15	37.15	37.15
72 hours	38.95	38.95	38.95	38.95	38.95
96 hours	40.31	40.31	40.31	40.31	40.31

TABLE 26: PMF RESULTS FROM HMS AT SELECTED NODES

HMS Node	Description	Drainage Area (mi^2)	PMF peak flows in cfs :			
			Orange Reservoir Dam	Lenape Park Detention Basin	Middlesex Reservoir	“Four Centerings”
SAA	Orange Reservoir Dam	4.61	27310	21510	7860	27310
SAA Comp	Peak inflow	4.61	27310	21510	7860	27310
Orange_ Res	Peak outflow	4.61	26630	20890	7520	26630
WESTBR	West Branch at mouth	8.19	25140	22350	9090	25520
EASTBR	East Branch at mouth	8.11	12920	16870	6830	16870
SPRDSI	USGS gage 01394500 Rahway River near Springfield	26.55	36690	46080	24700	47600
DSK	Lenape Park Detention Basin inflow	30.87	39320	53190	32720	54230
Lenape_ Park_Dam	Outflow	30.87	39120	53130	32380	54140

TABLE 26: PMF RESULTS FROM HMS AT SELECTED NODES (CONT.)

HMS Node	Description	Drainage Area (mi^2)	PMF peak flows in cfs :			
			Orange Reservoir Dam	Lenape Park Detention Basin	Middlesex Reservoir	"Four Centerings"
RAHDSM	USGS gage 01395000 Rahway River at Rahway NJ	41.19	22990	34420	20350	35610
UPROBC	Rahway River upstream of Robinson's Branch	41.61	22890	34290	20290	35500
120 COMB	Robinson's Branch : inflow to Middlesex Reservoir	20.83	9470	20120	29880	29880
121 ROUT	Middlesex Reservoir Outflow	20.83	8710	19580	29020	28480
123 COMB	USGS gage 01396000 Robinson's Branch at Rahway NJ	21.87	9380	20940	31040	30730
130 ROBI	Robinson's Branch at mouth	22.92	8360	18920	28980	29320
DSROBC	Rahway River downstream of Robinson's Branch	64.53	24160	38860	38430	43350

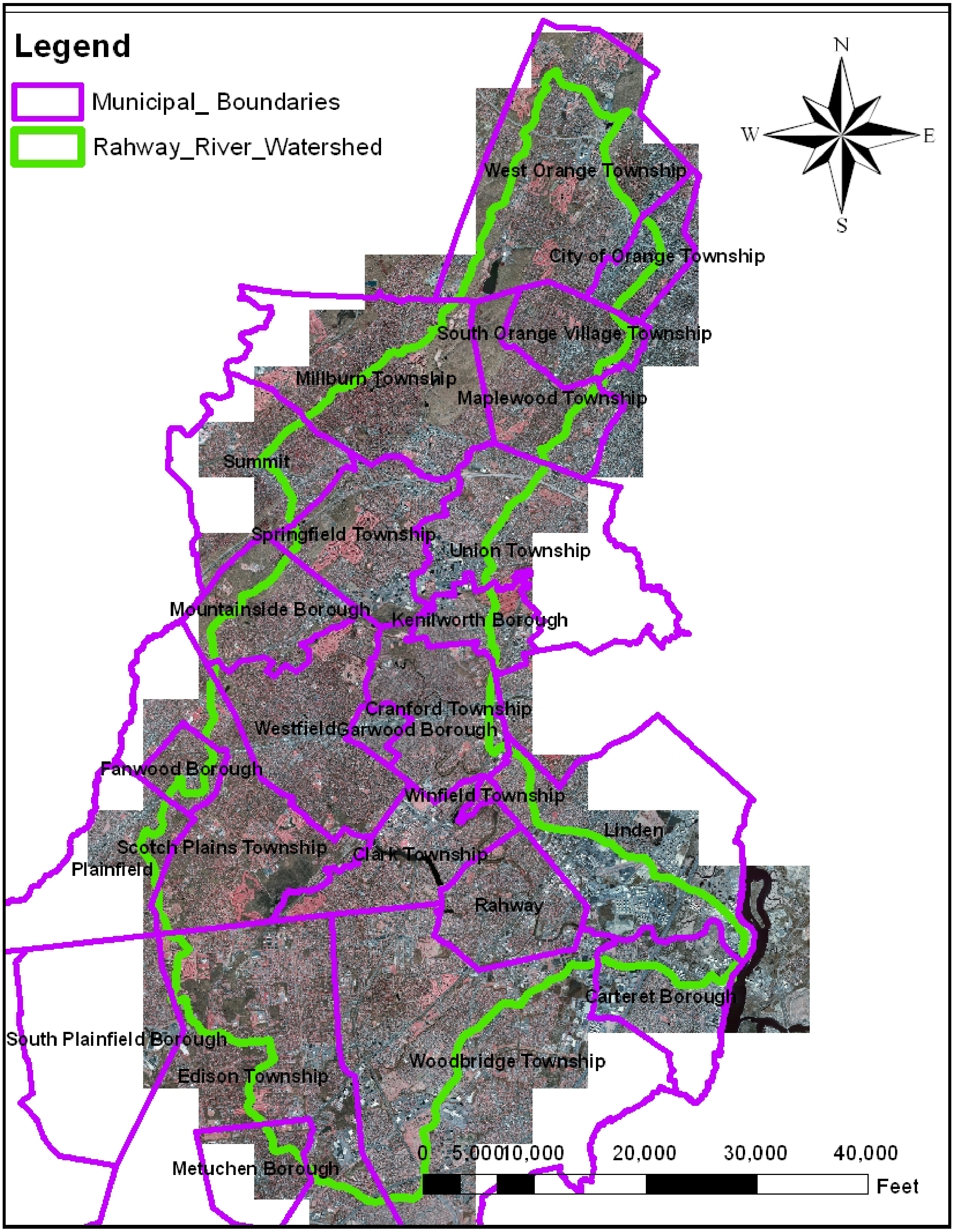

FIGURE 1: RAHWAY RIVER BASIN WITH CORRESPONDING MUNICIPALITIES

FIGURE 2 (A): PROJECT AREA SHOWNING DAMAGE CENTERS IN CRANFORD, NJ

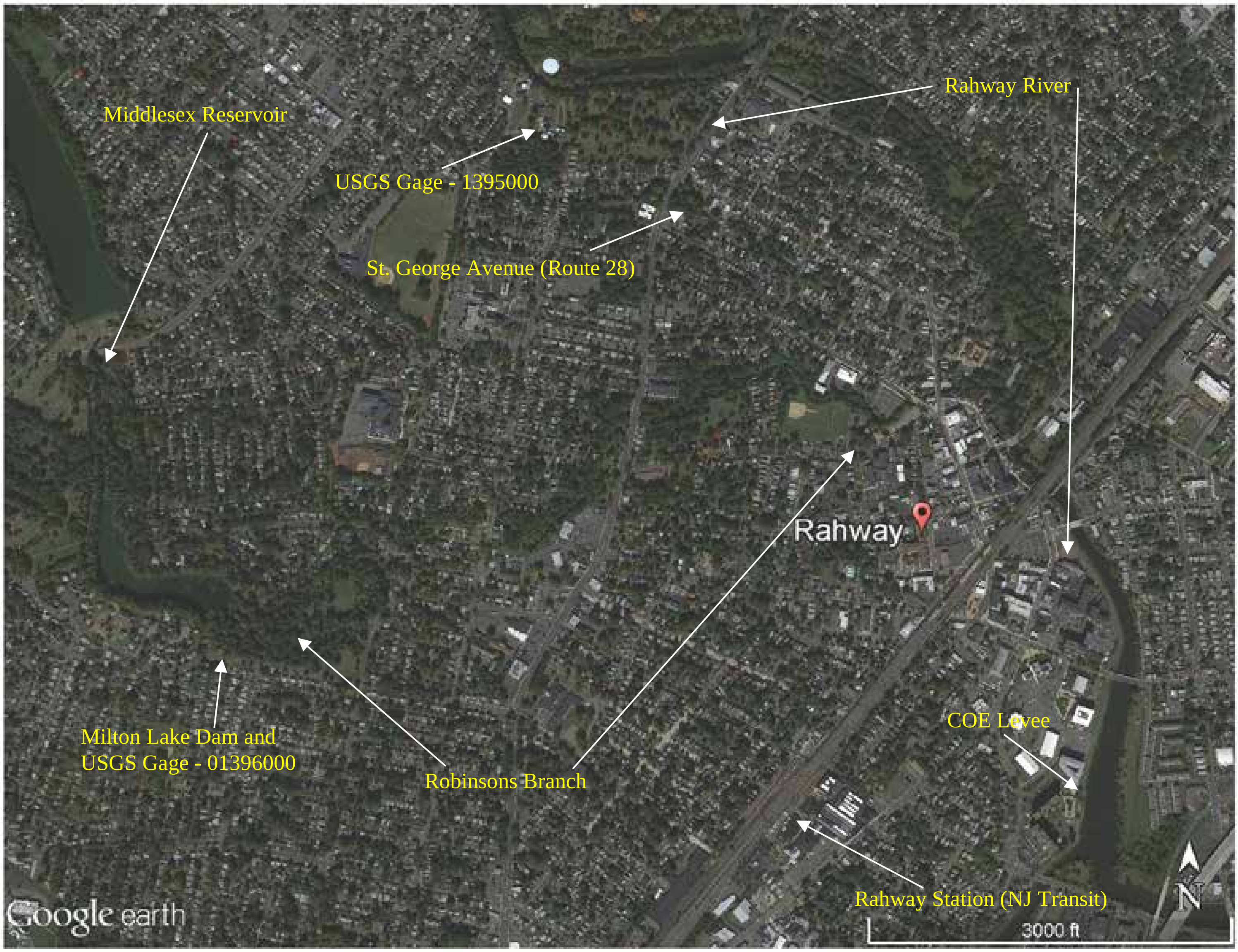

FIGURE 2 (B): PROJECT AREA SHOWING DAMAGE CENTERS IN RAHWAY, NJ

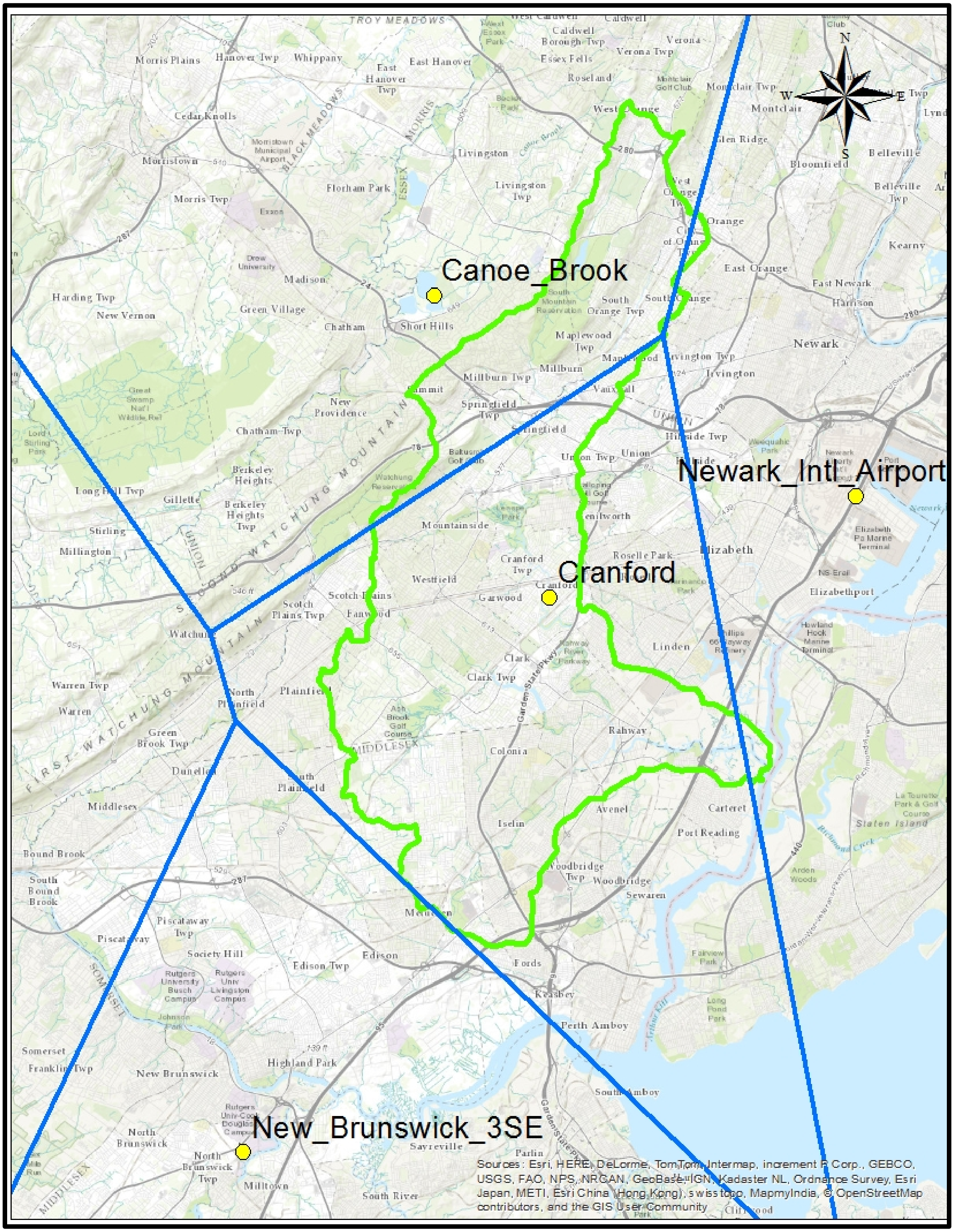

FIGURE 3: THIESSEN POLYGON SHOWING RAINFALL GAGES FOR APRIL 2007

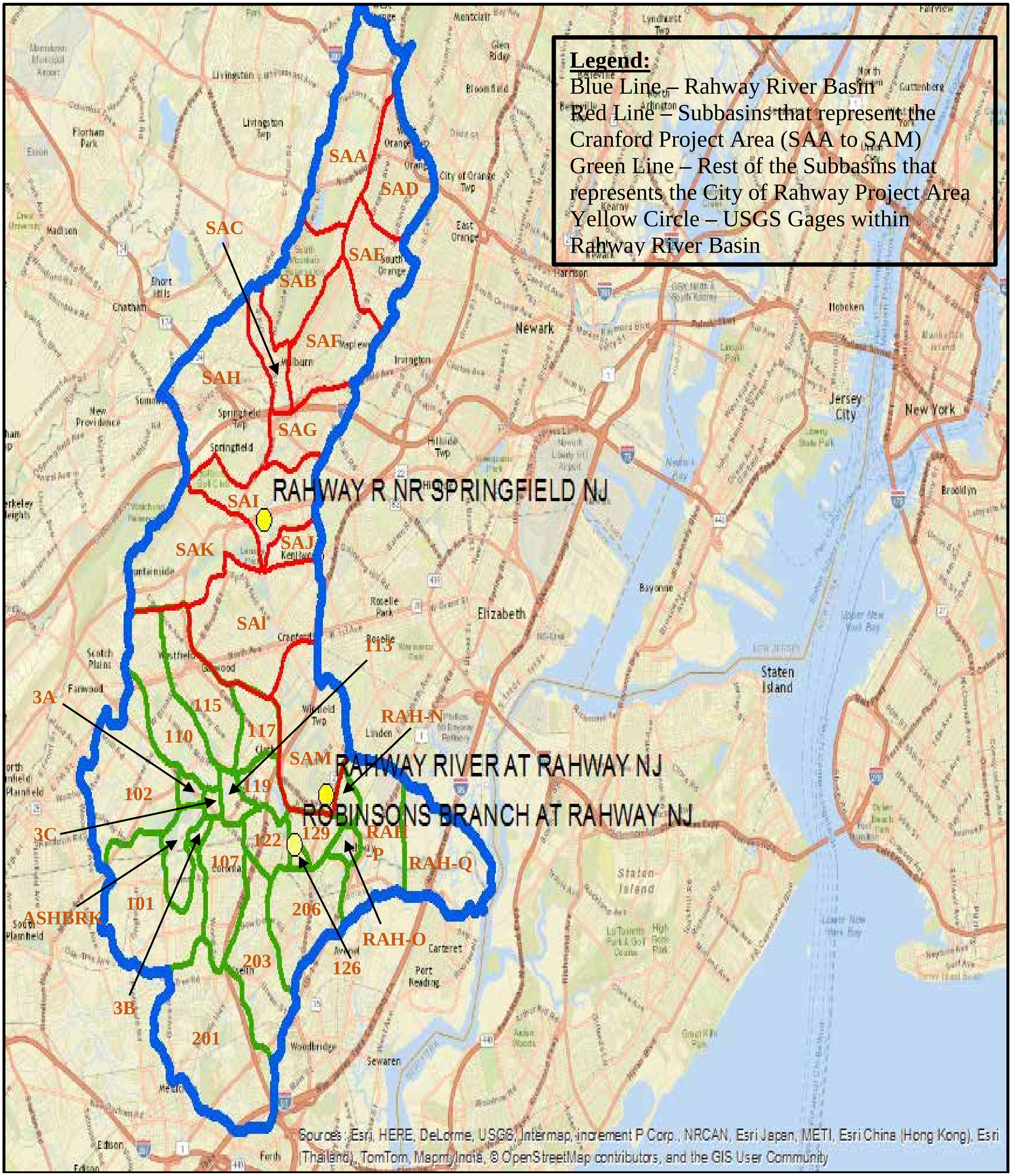

FIGURE 4: SUBBASIN AS USED IN HEC-HMS MODEL WITH USGS STREAM GAGES

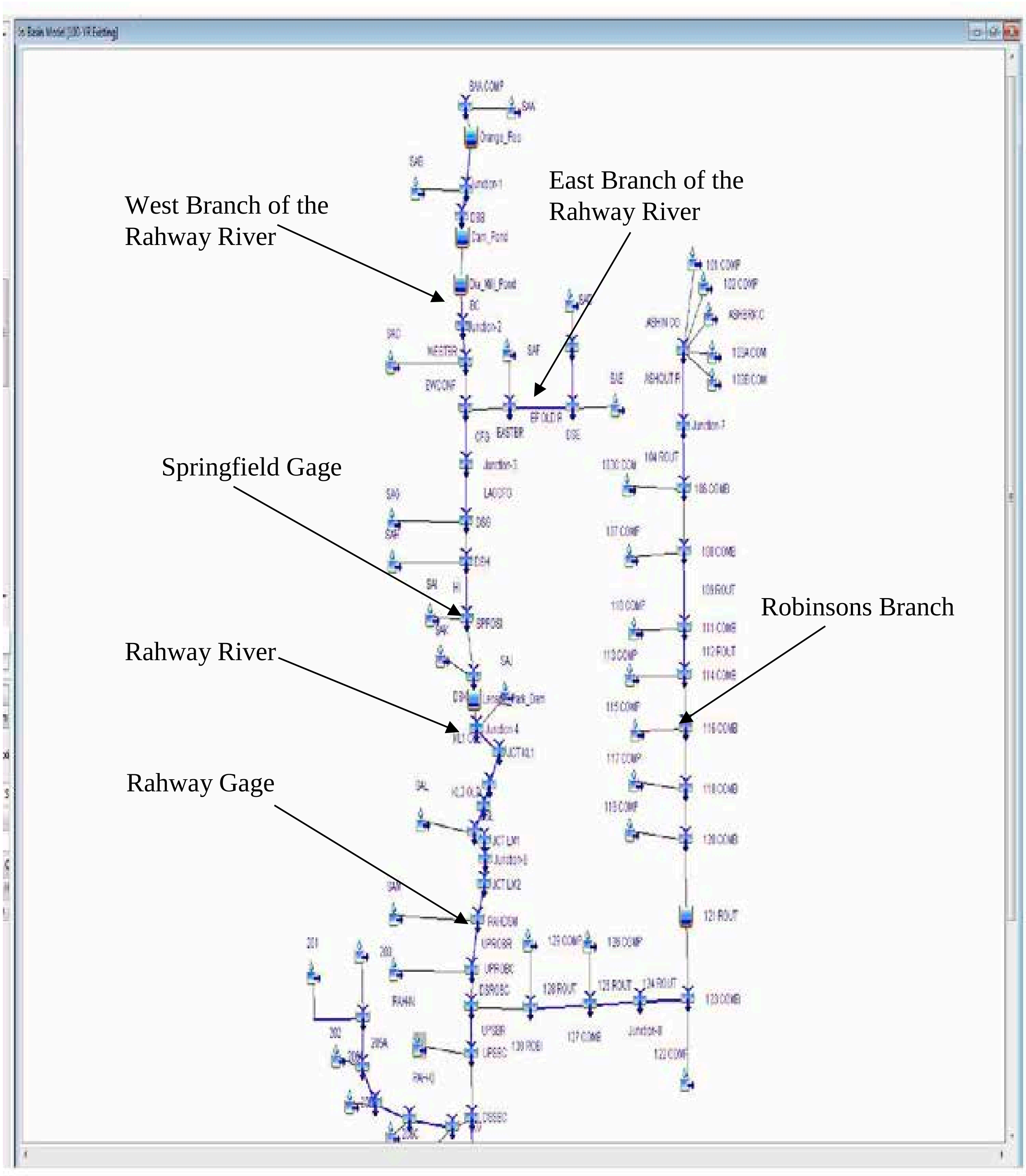

FIGURE 5: SCHEMATIC DIAGRAM OF HEC-HMS MODEL

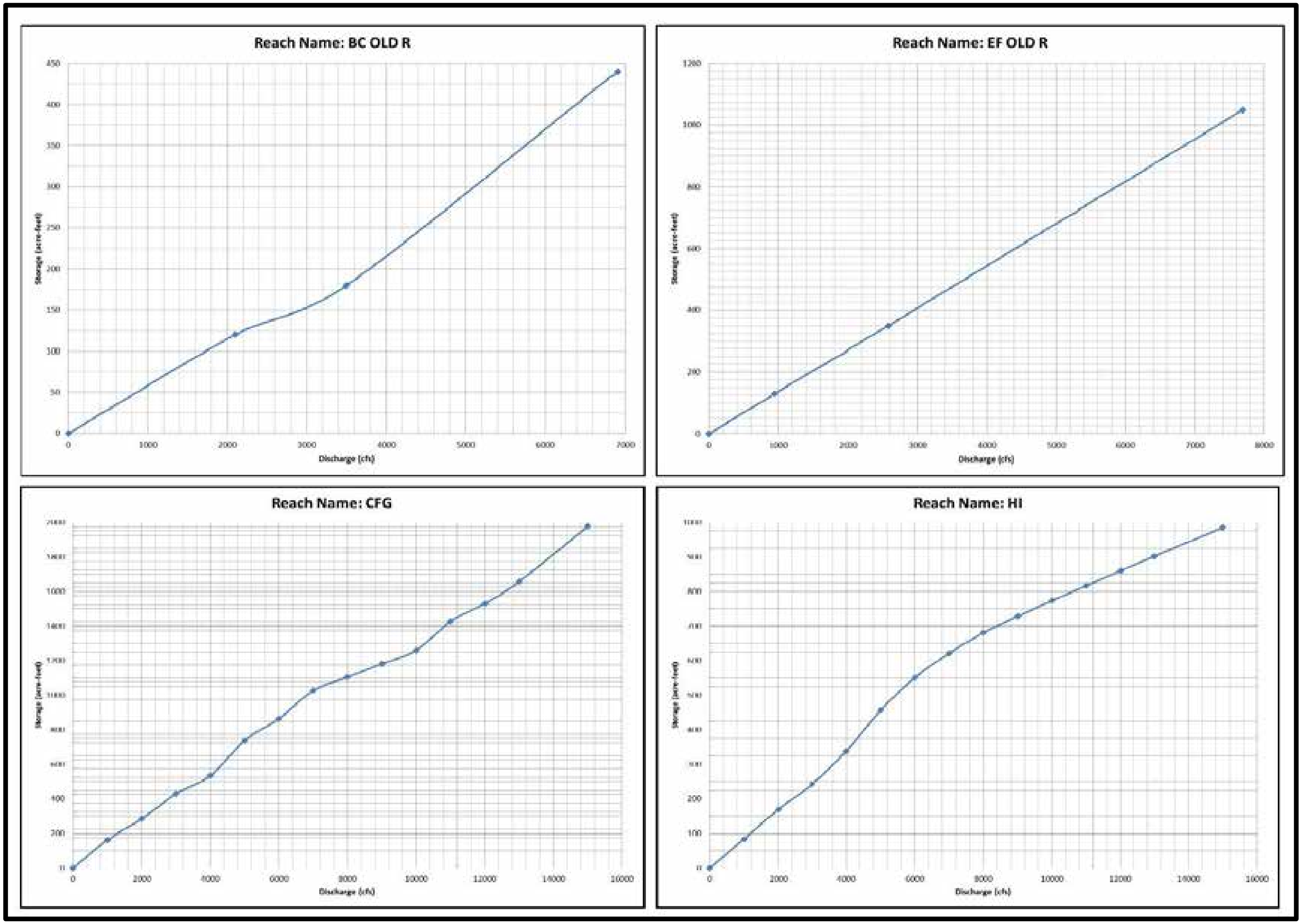

FIGURE 6(A): MODIFIED PULS ROUTING RELATIONS

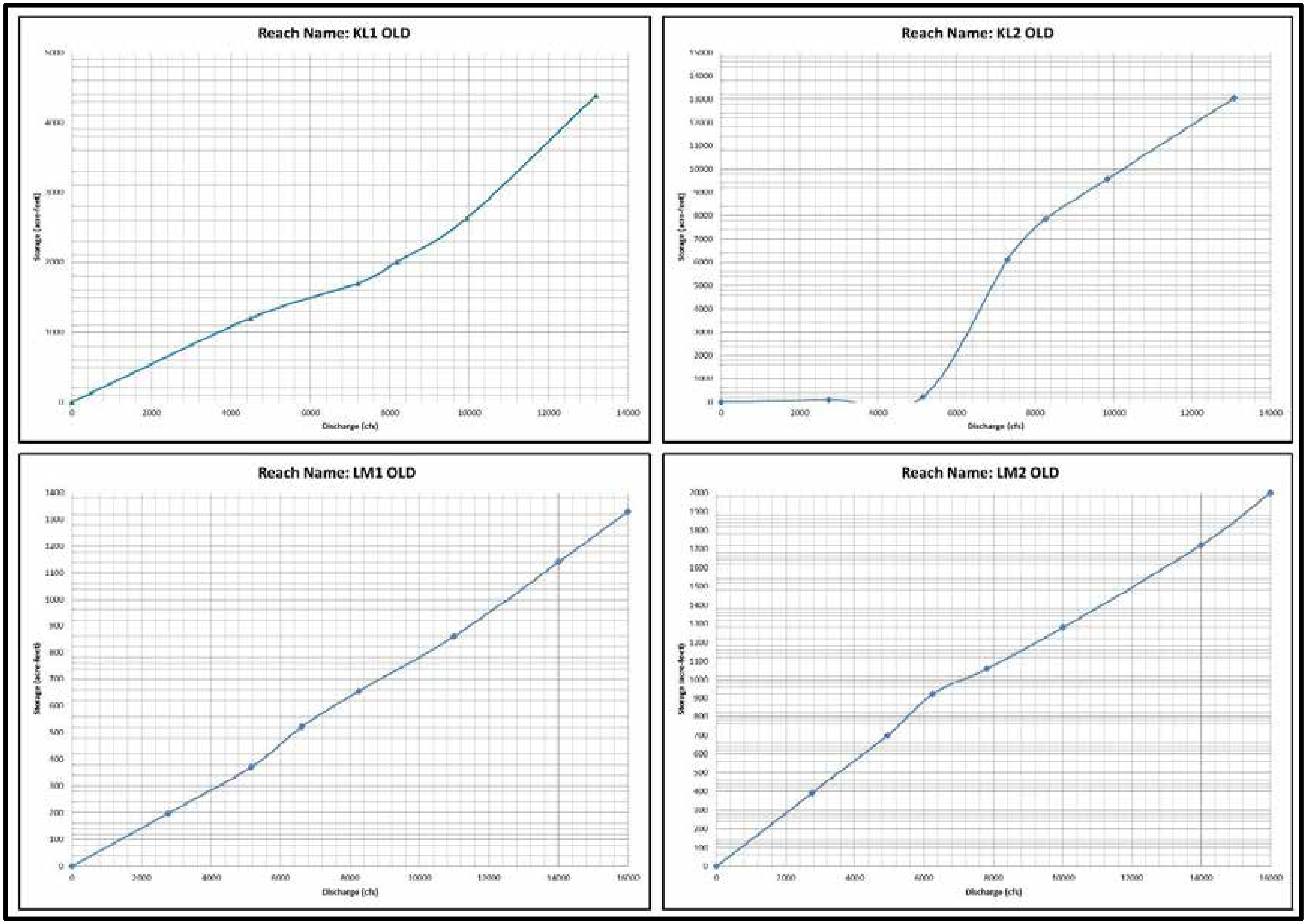

FIGURE 6(B): MODIFIED PULS ROUTING RELATIONS

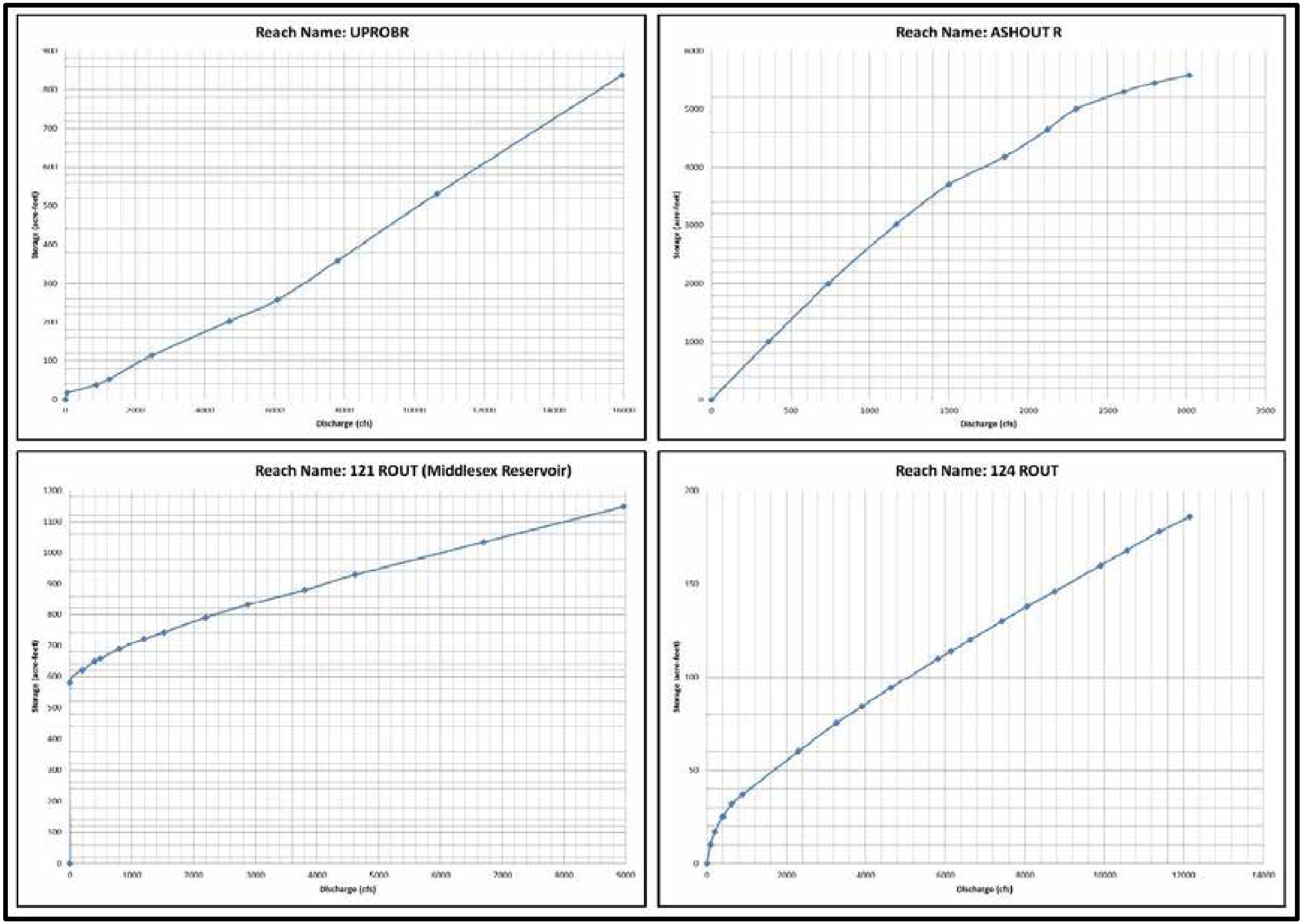

FIGURE 6(C): MODIFIED PULS ROUTING RELATIONS

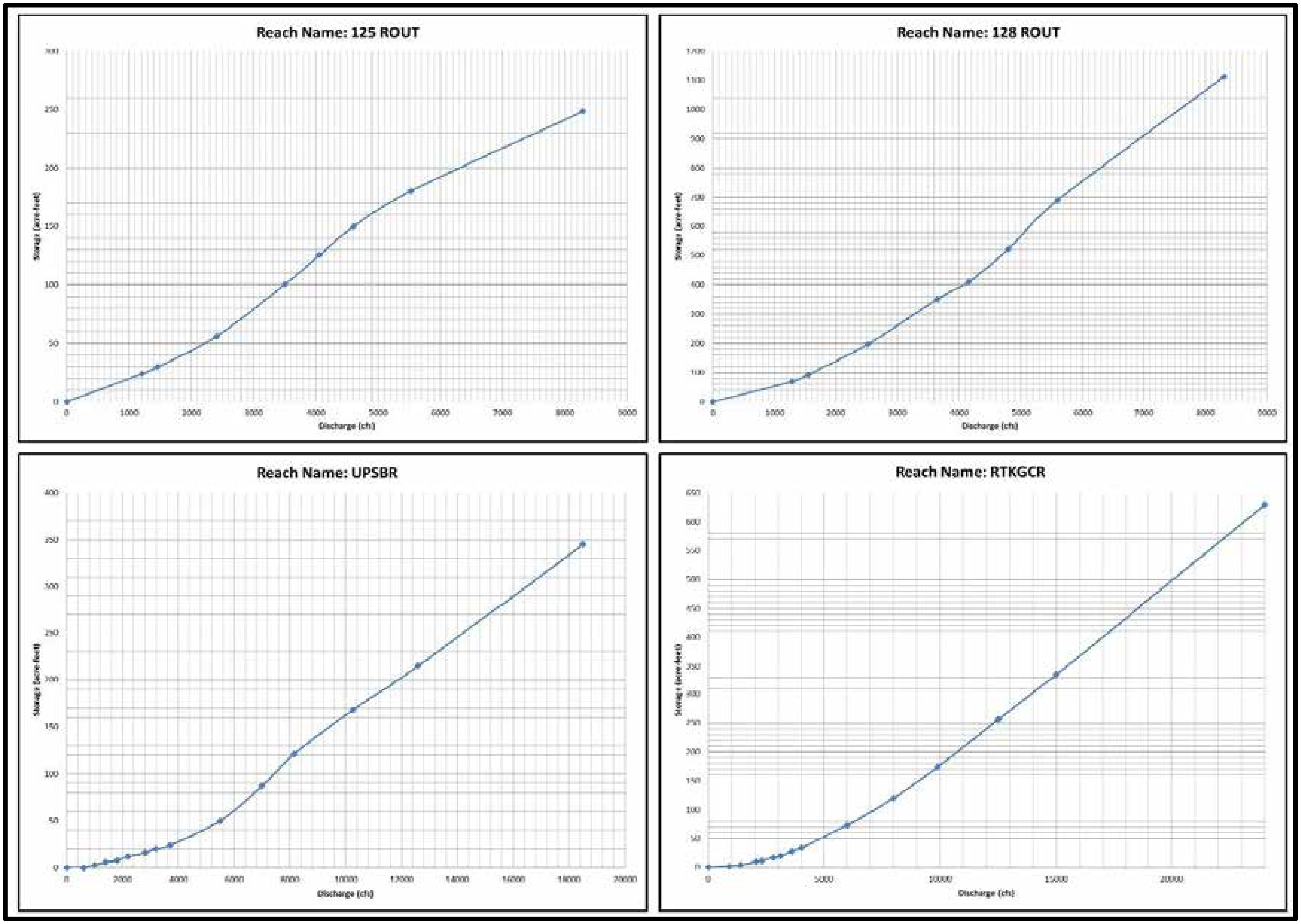

FIGURE 6(D): MODIFIED PULS ROUTING RELATIONS

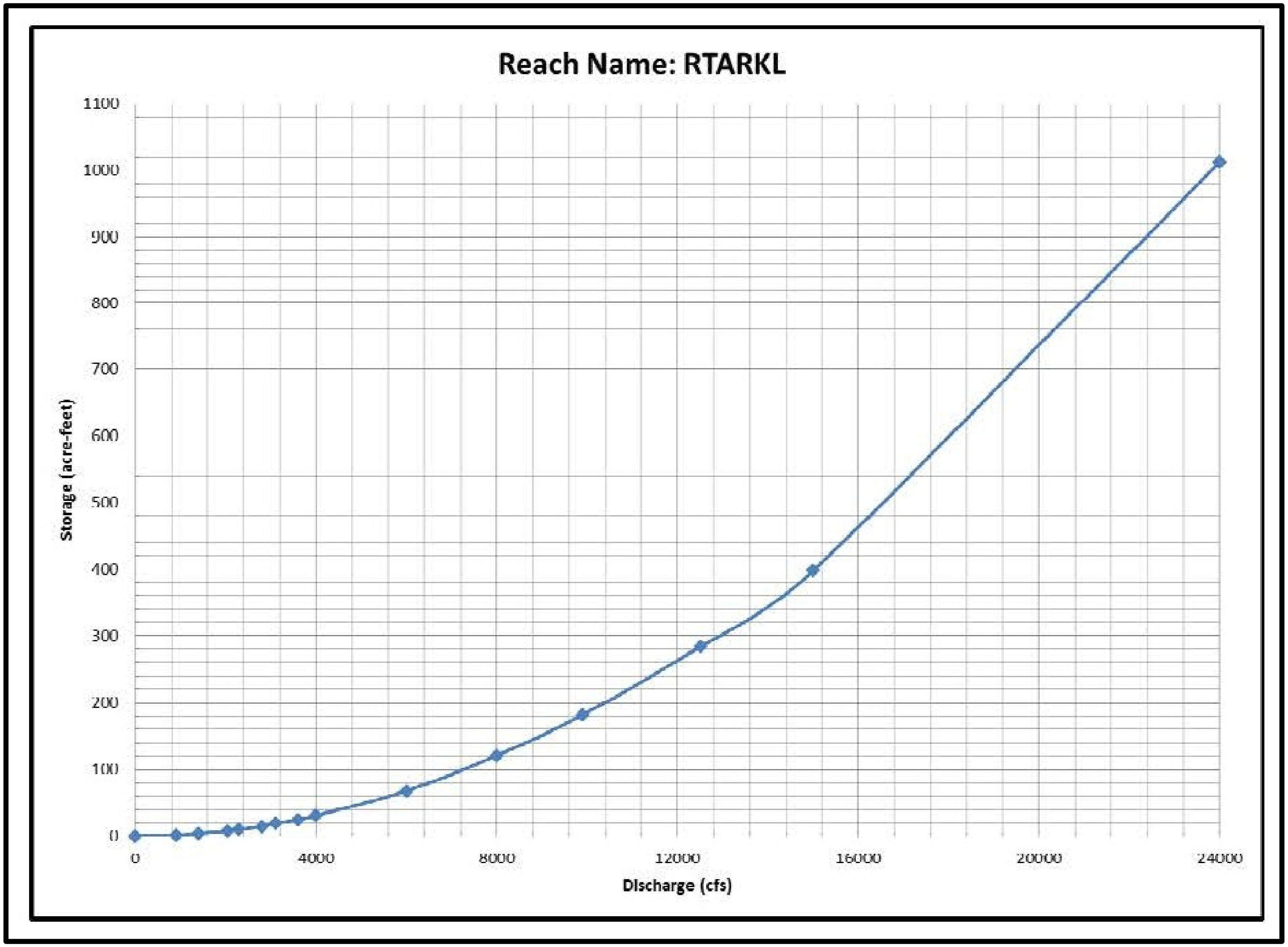

FIGURE 6(E): MODIFIED PULS ROUTING RELATIONS

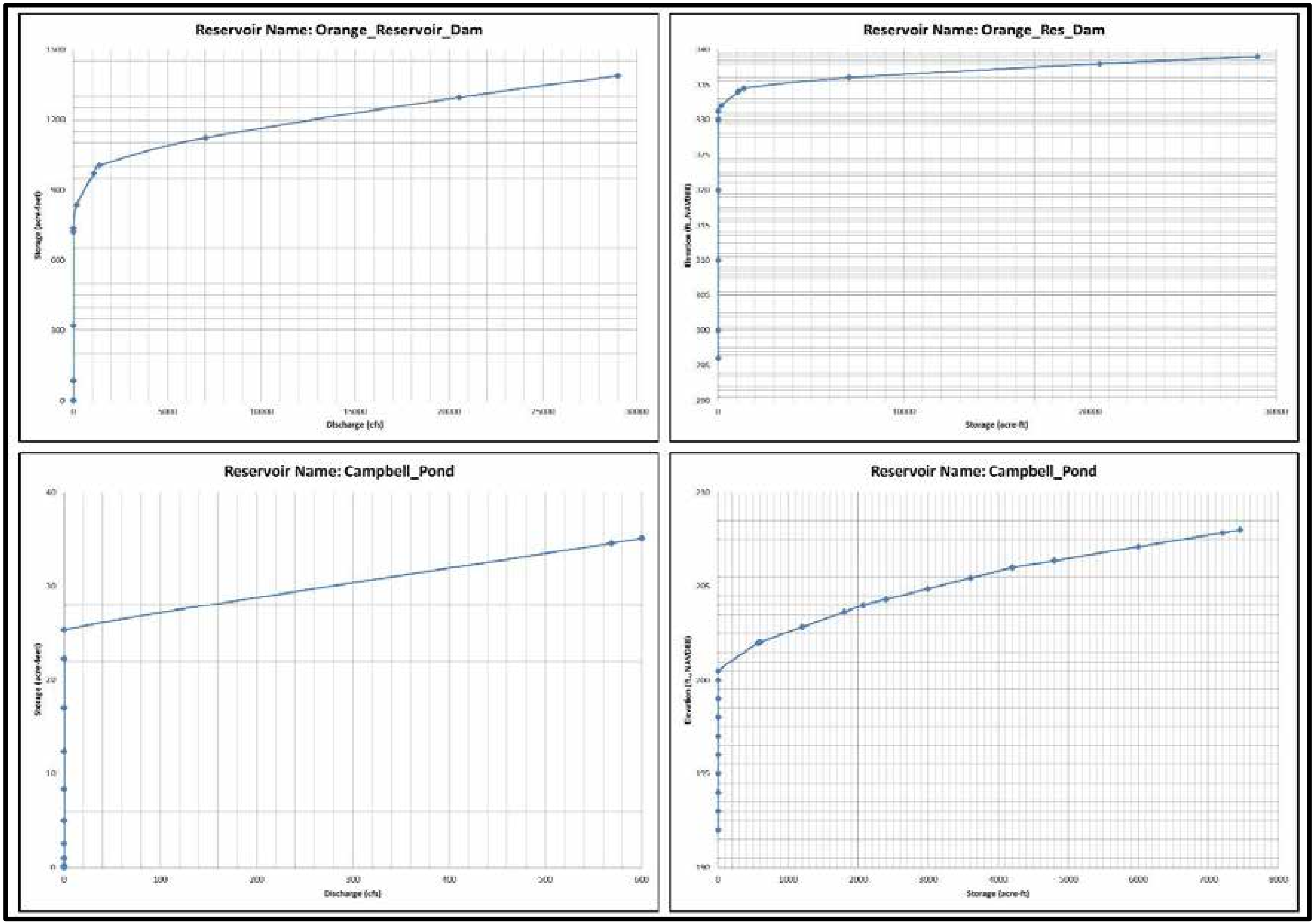

FIGURE 6(F): RESERVOIR ROUTING RELATIONS

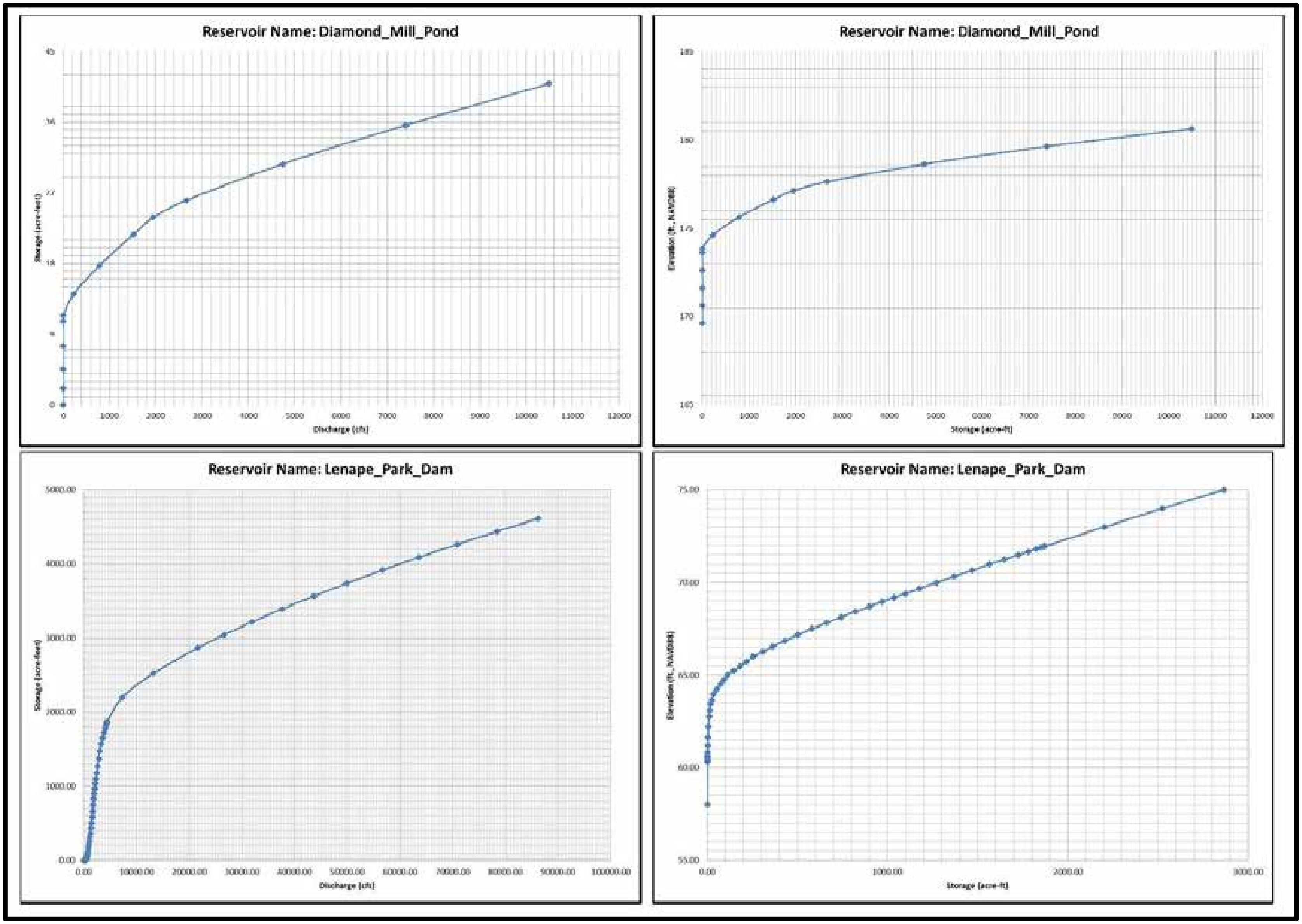

FIGURE 6(G): RESERVOIR ROUTING RELATIONS

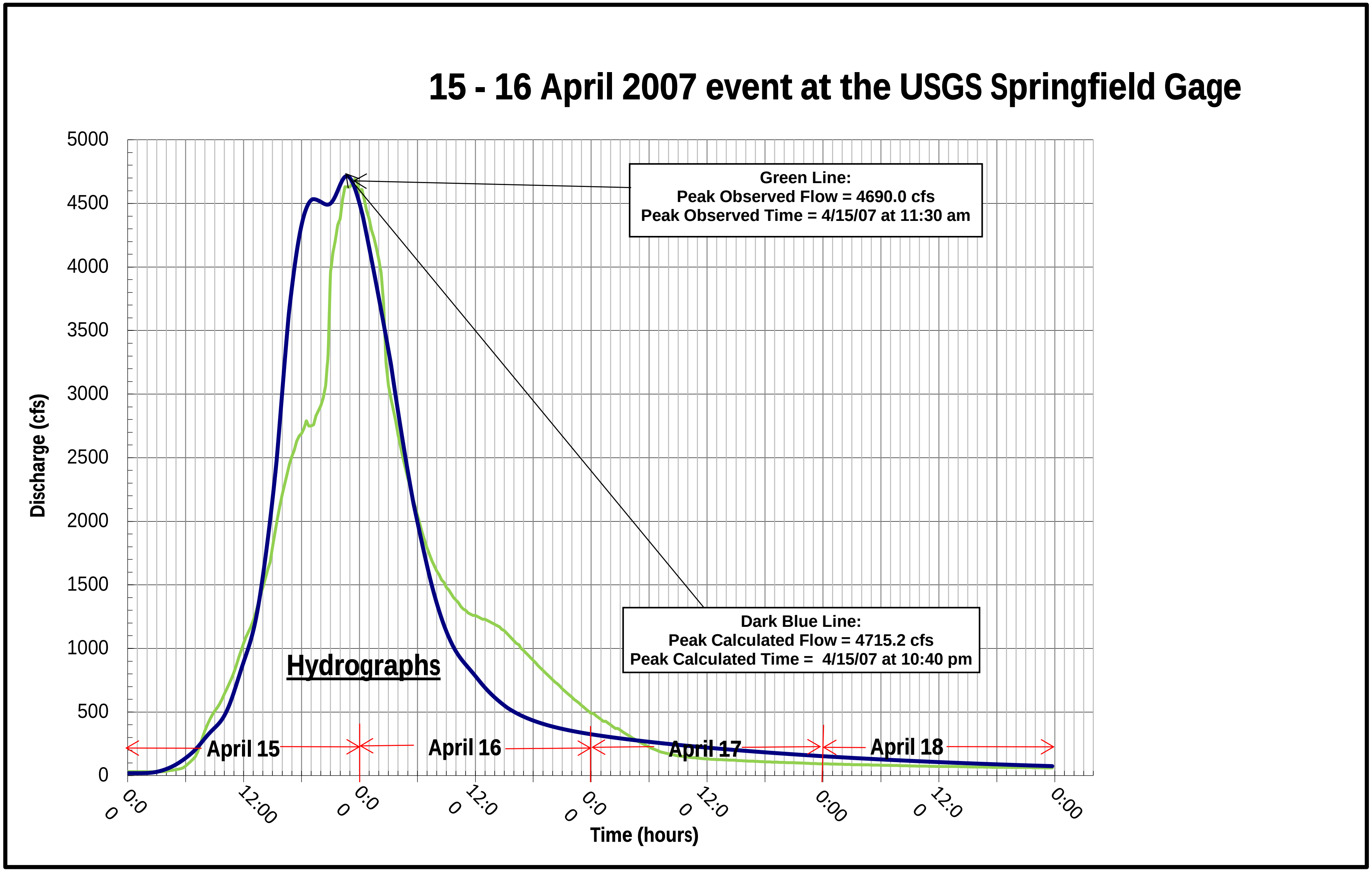

FIGURE 7: OBSERVED HYDROGRAH REPRODUCTION AT SPRINGFIELD USGS GAGE FOR THE 15-16 APRIL 2007 EVENT

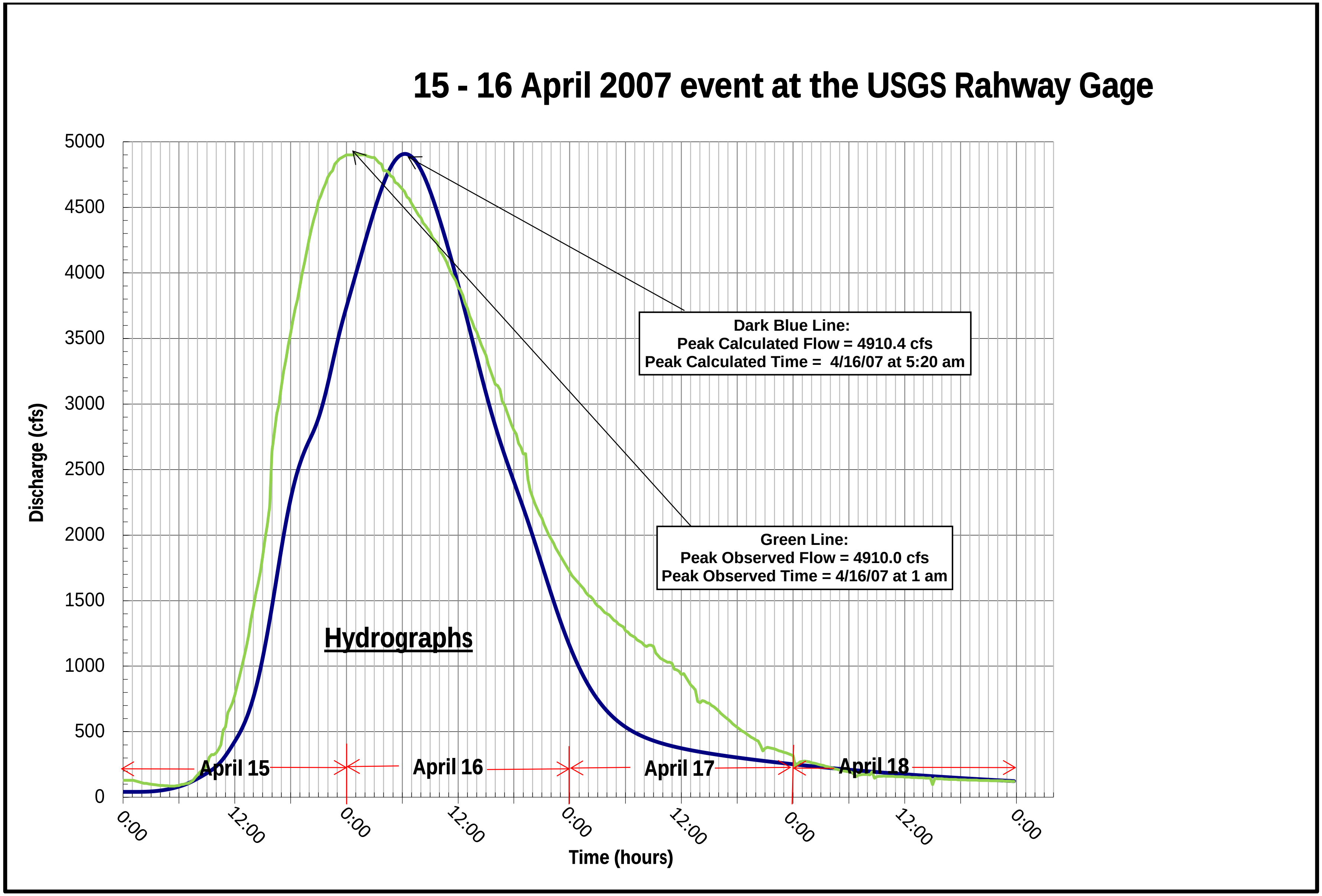

FIGURE 8: OBSERVED HYDROGRAH REPRODUCTION AT RAHWAY USGS GAGE FOR THE 15-16 APRIL 2007 EVENT

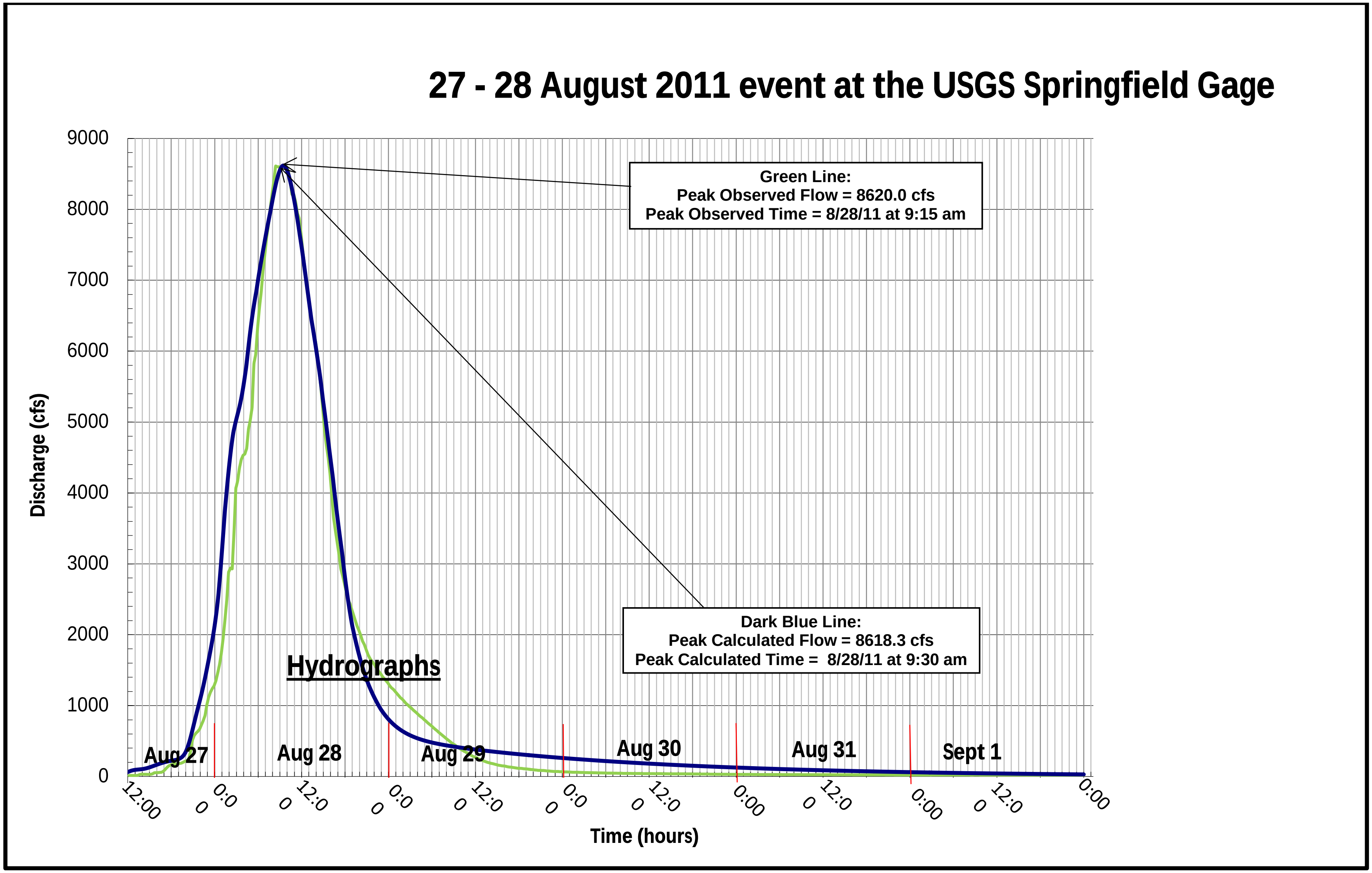

FIGURE 9: OBSERVED HYDROGRAH REPRODUCTION AT SPRINGFIELD USGS GAGE FOR THE TROPICAL CYCLONE IRENE (27-28 2011) EVENT

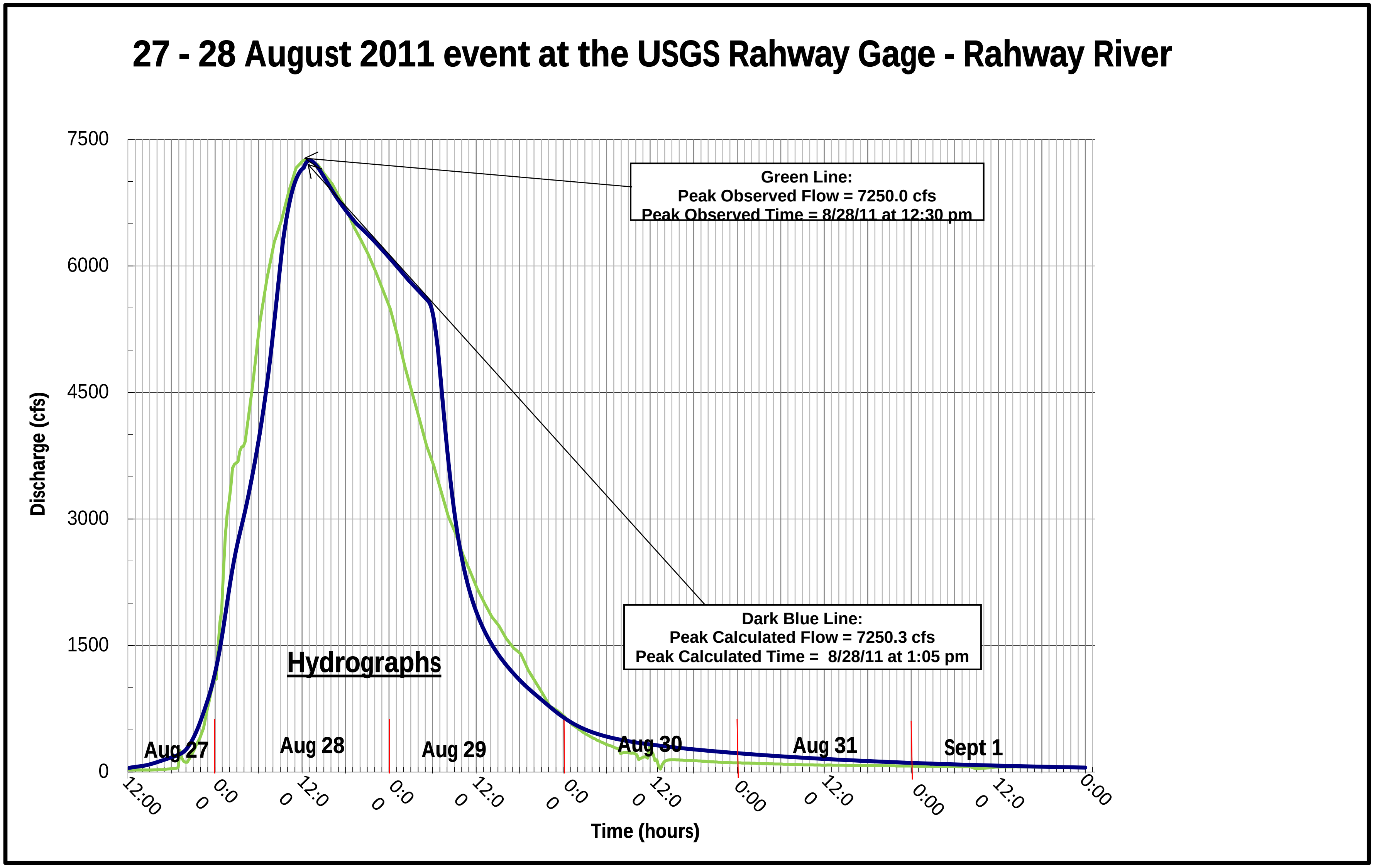

FIGURE 10: OBSERVED HYDROGRAH REPRODUCTION AT RAHWAY USGS GAGE FOR THE TROPICAL CYCLONE IRENE (27-28 AUGUST 2011) EVENT

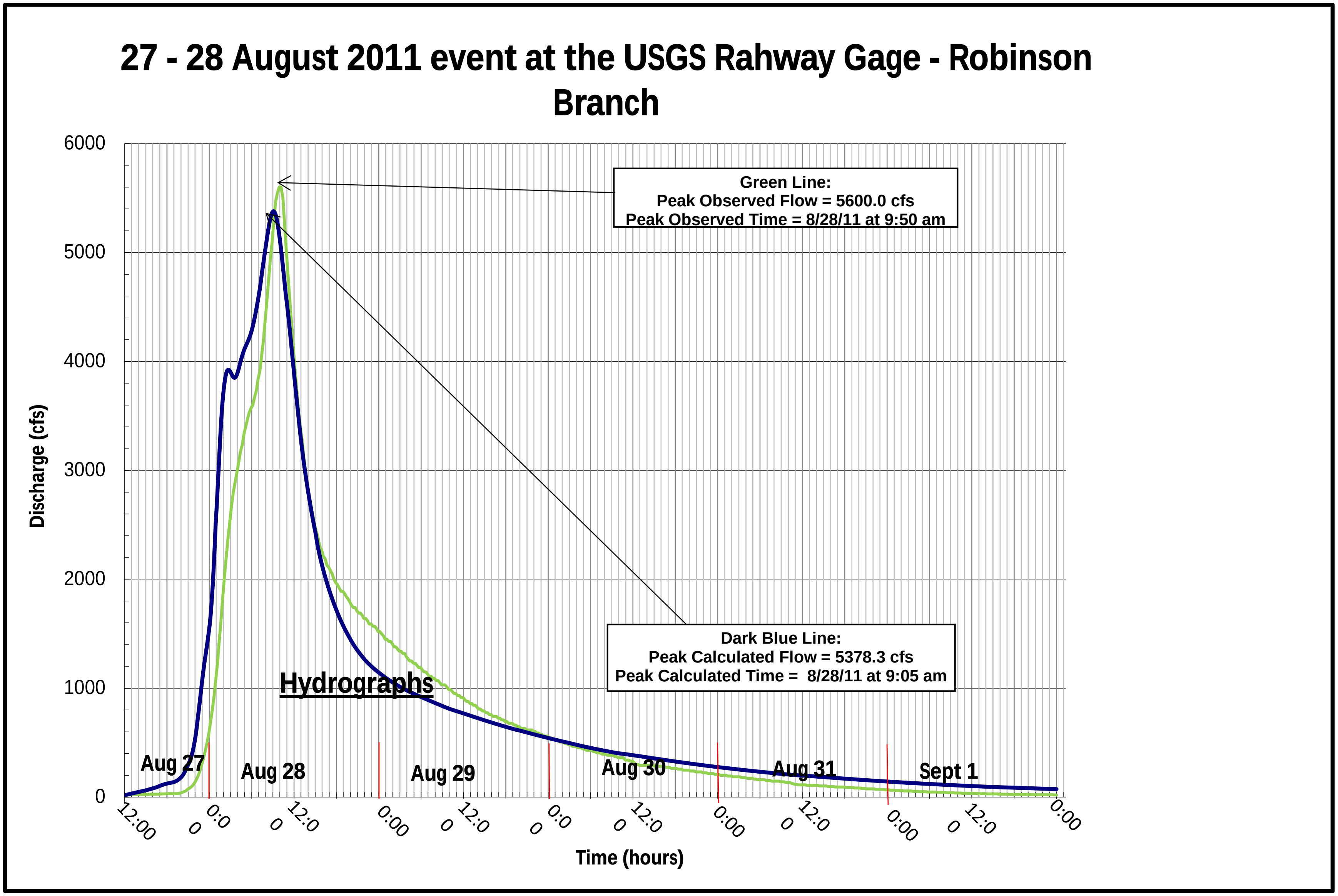

FIGURE 11: OBSERVED HYDROGRAPH REPRODUCTION AT ROBINSON BRANCH USGS GAGE FOR THE TROPICAL CYCLONE IRENE (27-28 AUGUST 2011) EVENT

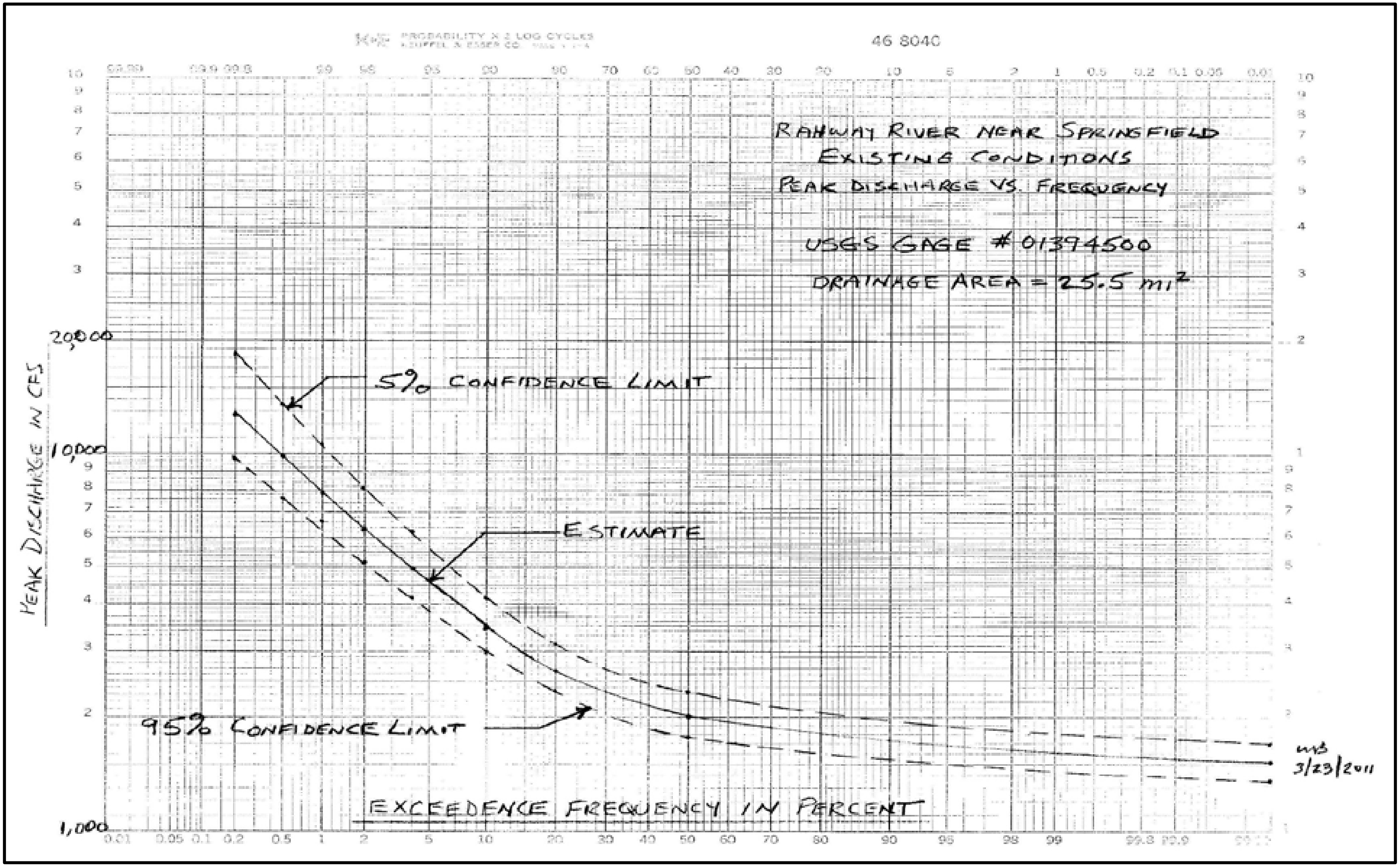

FIGURE 12: EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE WITH CONFIDENCE BANDS AT THE SRPINGFIELD GAGE UP TO WY2009

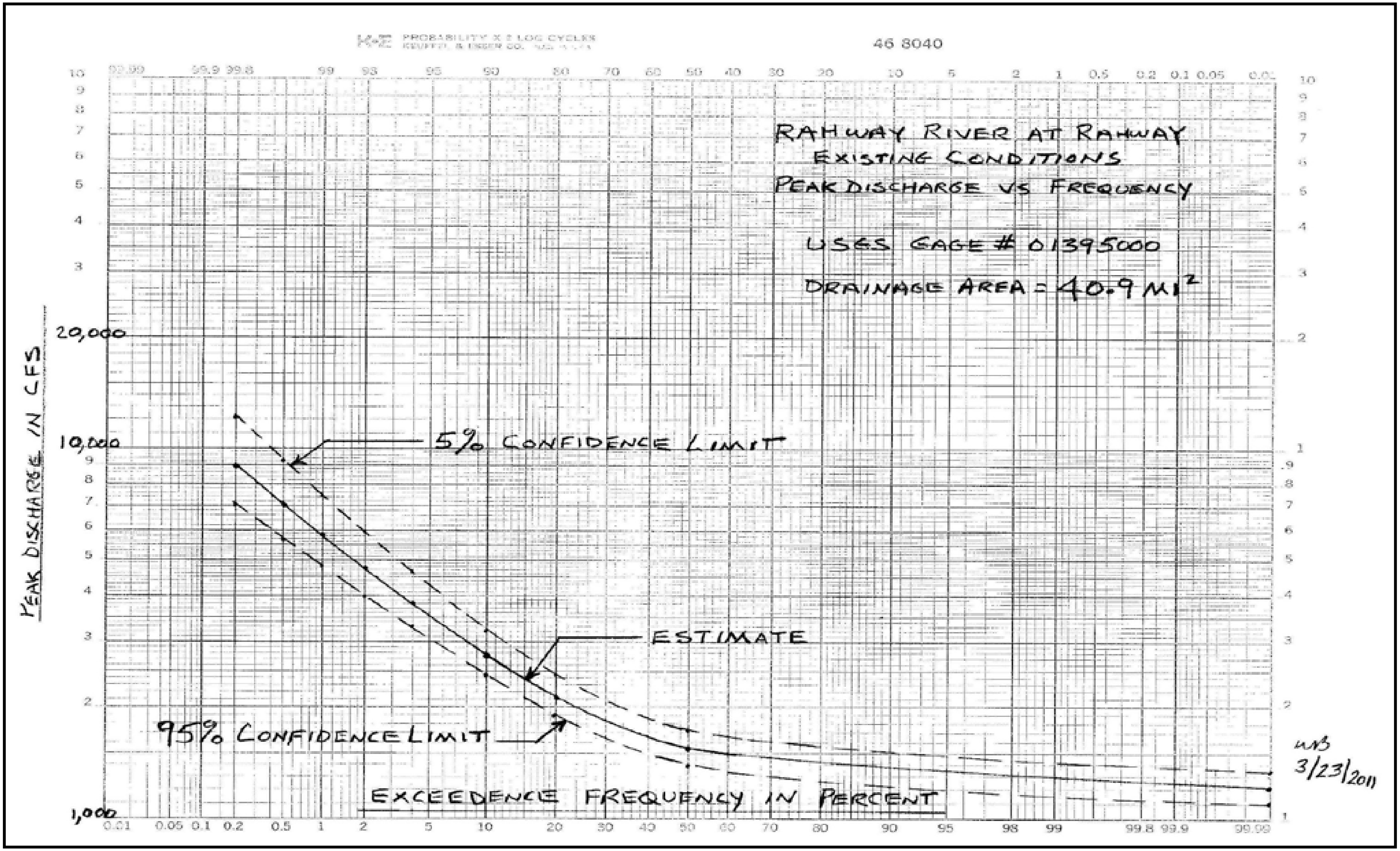

FIGURE 13: EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE WITH CONFIDENCE BANDS AT THE RAHWAY GAGE UP TO WY 2009

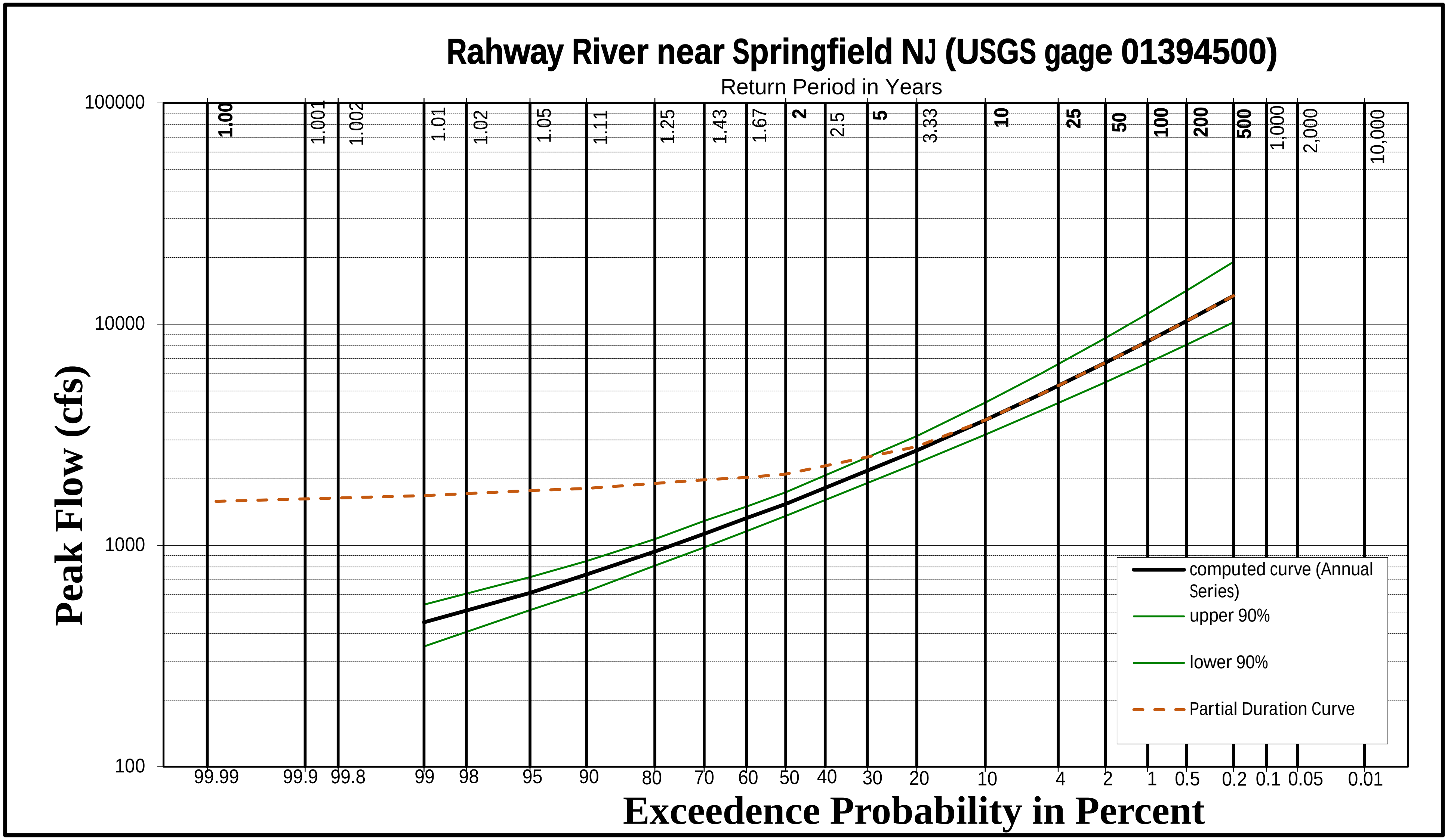

FIGURE 14: EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE WITH CONFIDENCE BANDS AT THE SRPINGFIELD GAGE UP TO WY2013

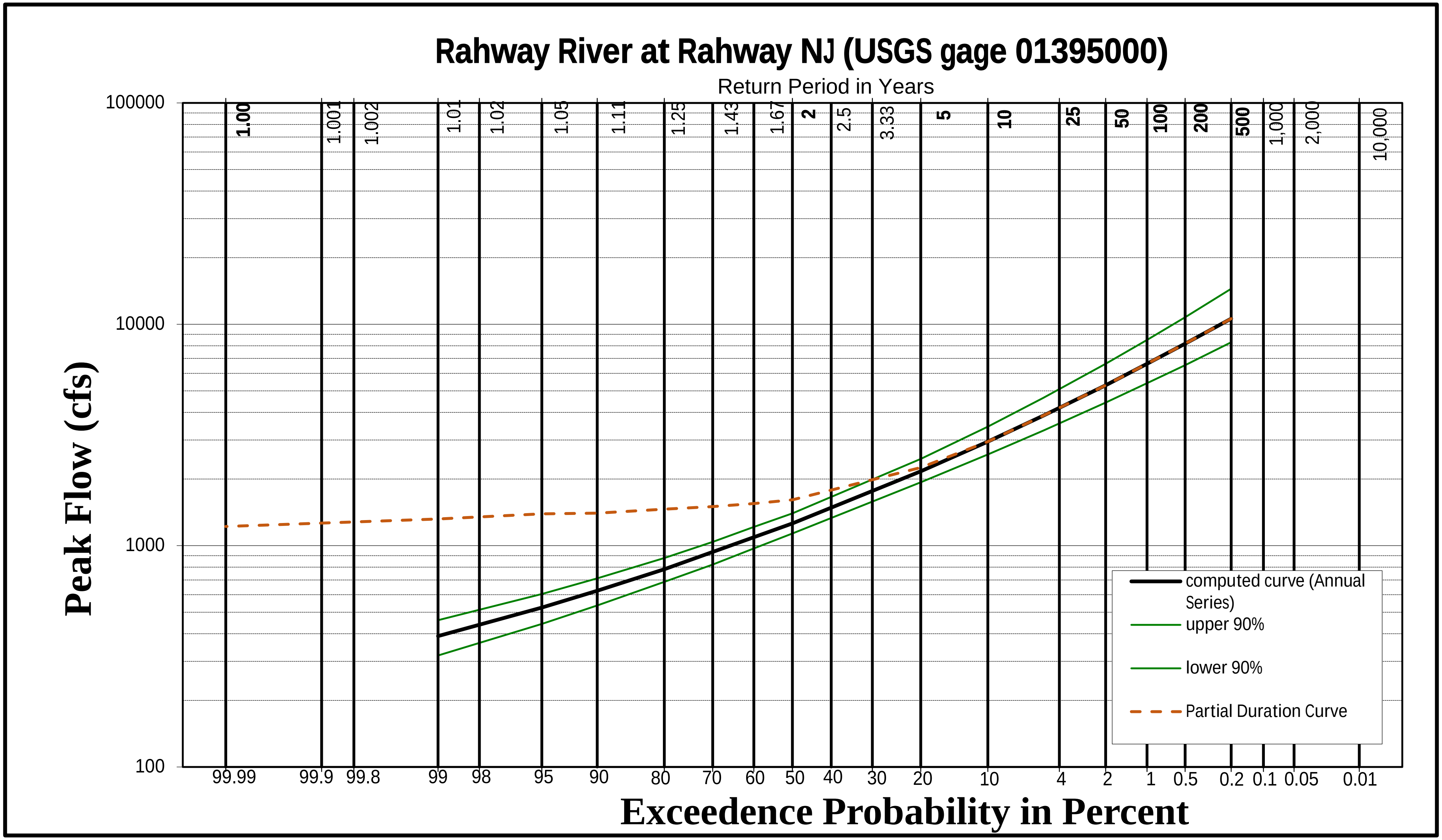

FIGURE 15: EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE WITH CONFIDENCE BANDS AT THE RAHWAY GAGE UP TO WY 2013

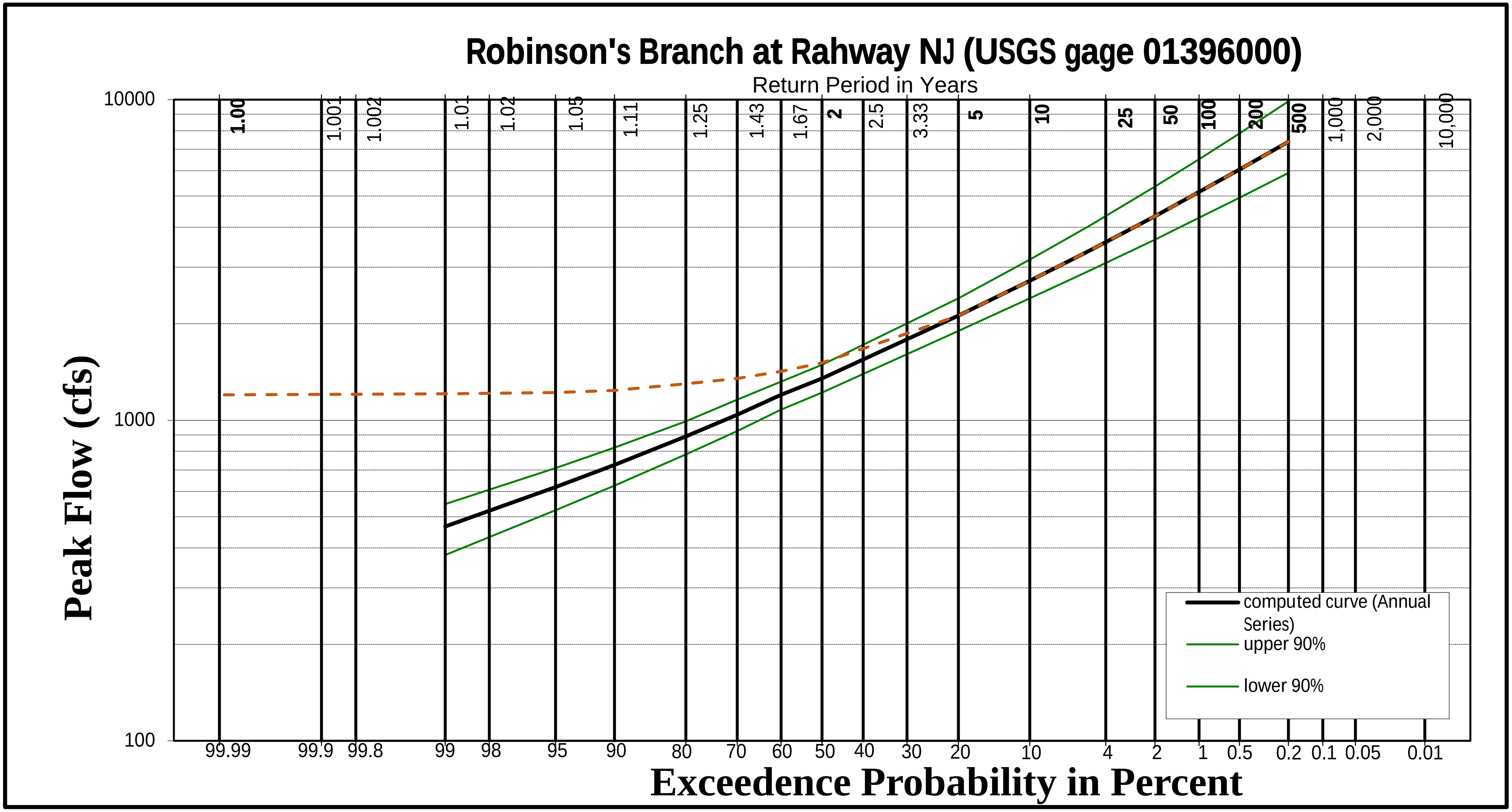

FIGURE 16: EXISTING CONDITIONS PEAK DISCHARGE VS. FREQUENCY CURVE WITH CONFIDENCE BANDS AT THE ROBINSON BRANCH GAGE UP TO WY 2013

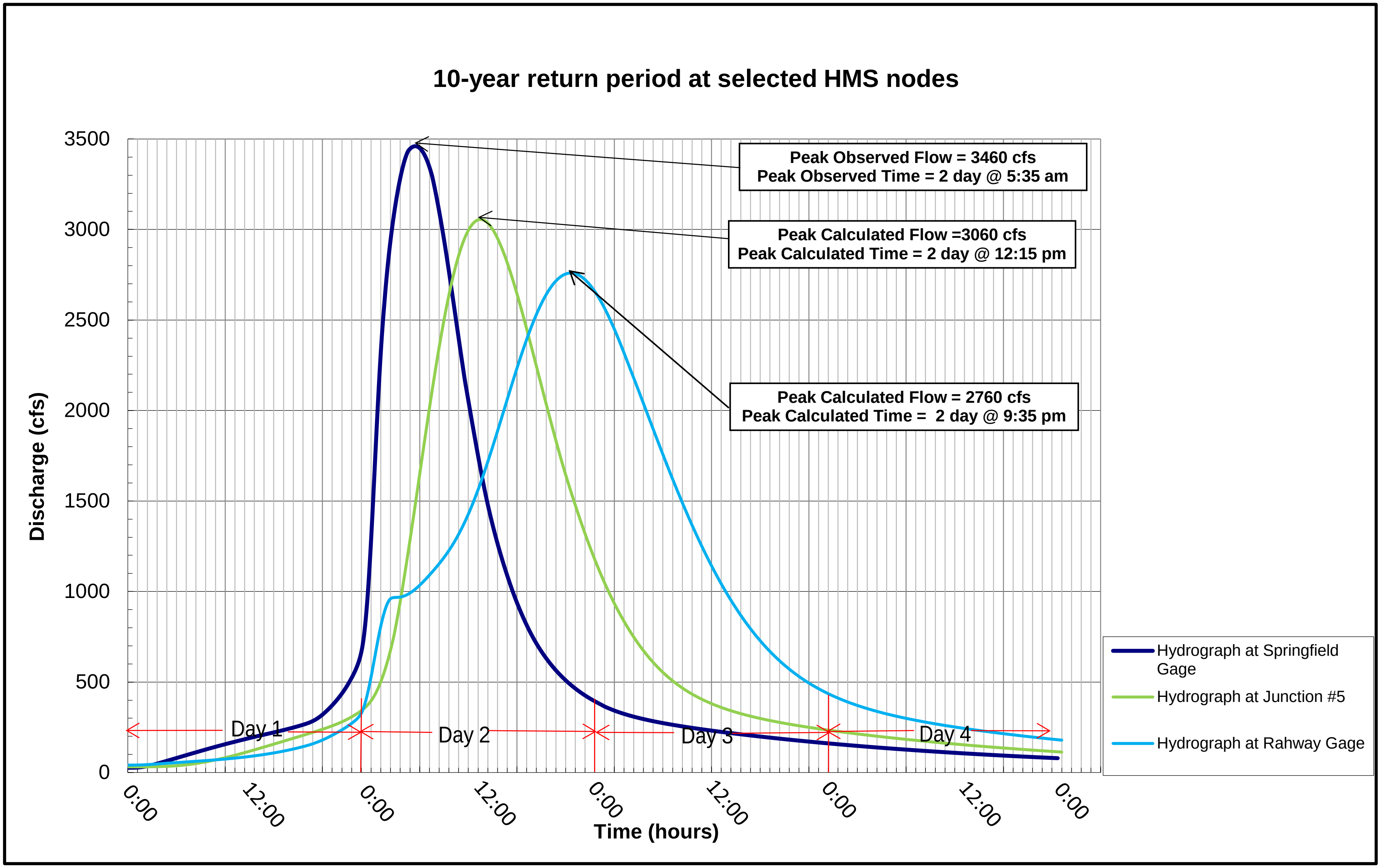

FIGURE 17: HYPOTHETICAL FLOOD (10-YEAR) AT SELECTED NODES ALONG THE RAHWAY RIVER FOR THE CRANFORD PROJECT AREA

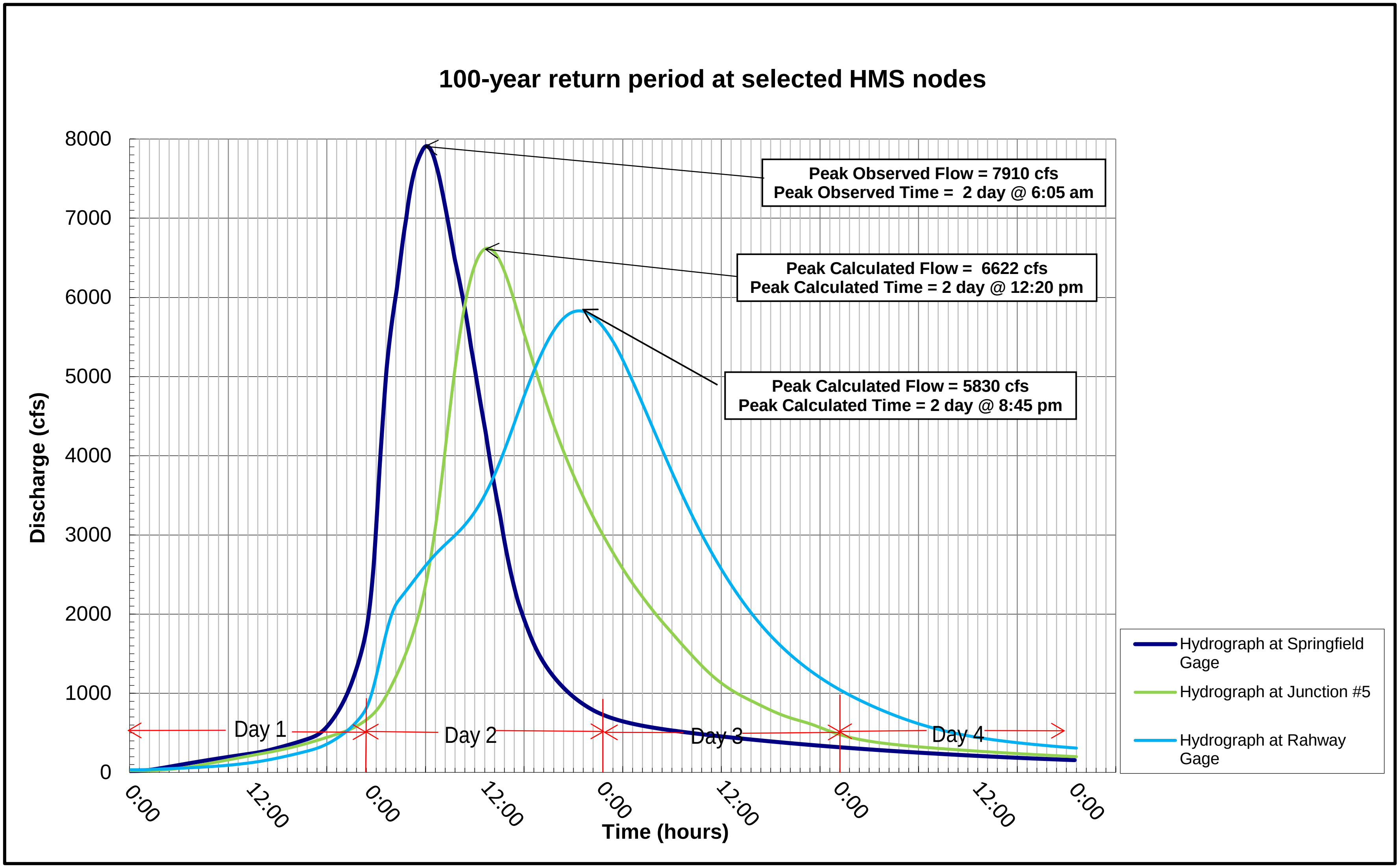

FIGURE 18: HYPOTHETICAL FLOOD (100-YEAR) AT SELECTED NODES ALONG THE RAHWAY RIVER FOR THE CRANFORD PROJECT AREA

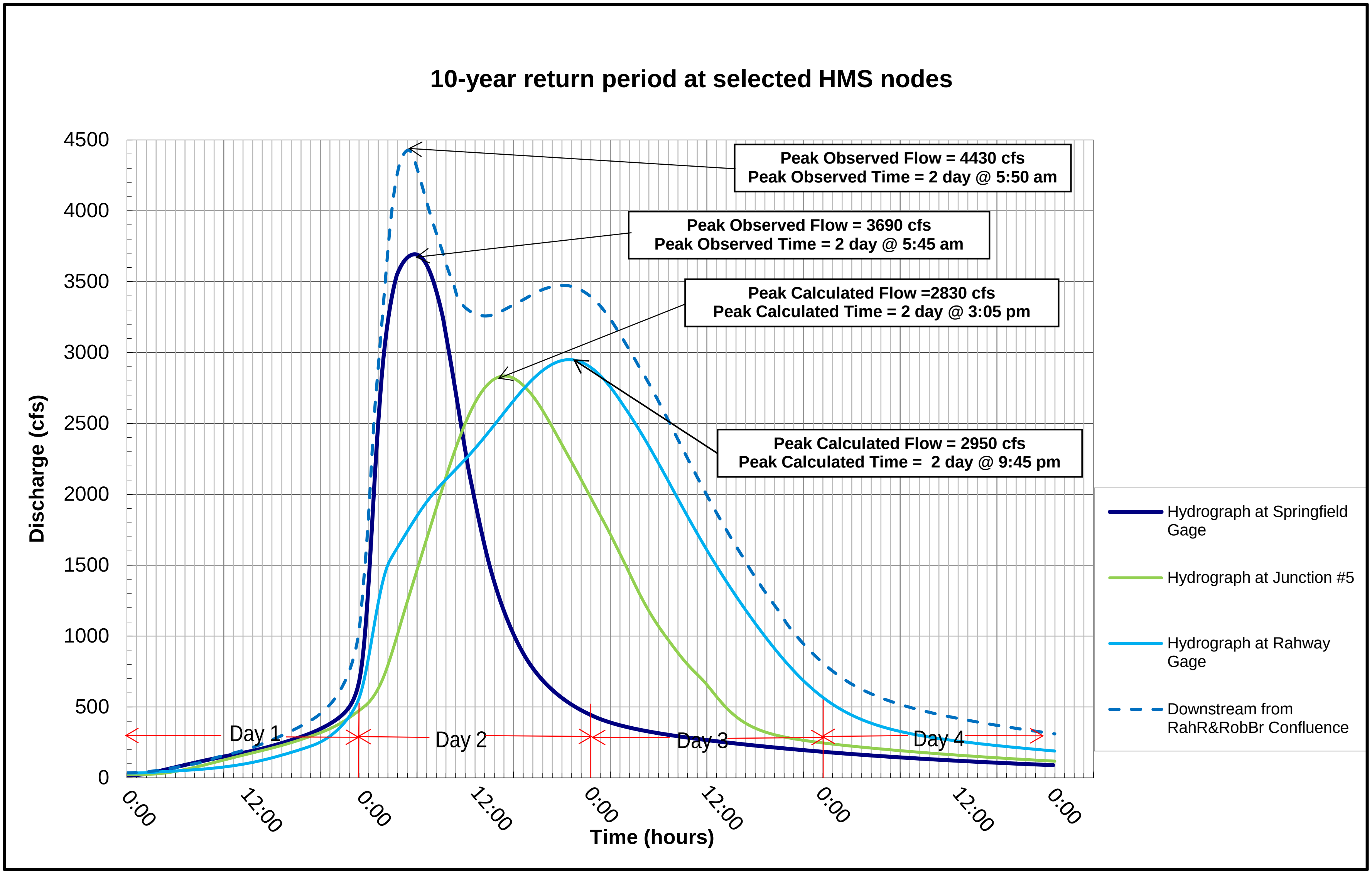

FIGURE 19: HYPOTHETICAL FLOOD (10-YEAR) AT SELECTED NODES ALONG THE RAHWAY RIVER FOR THE RAHWAY PROJECT AREA

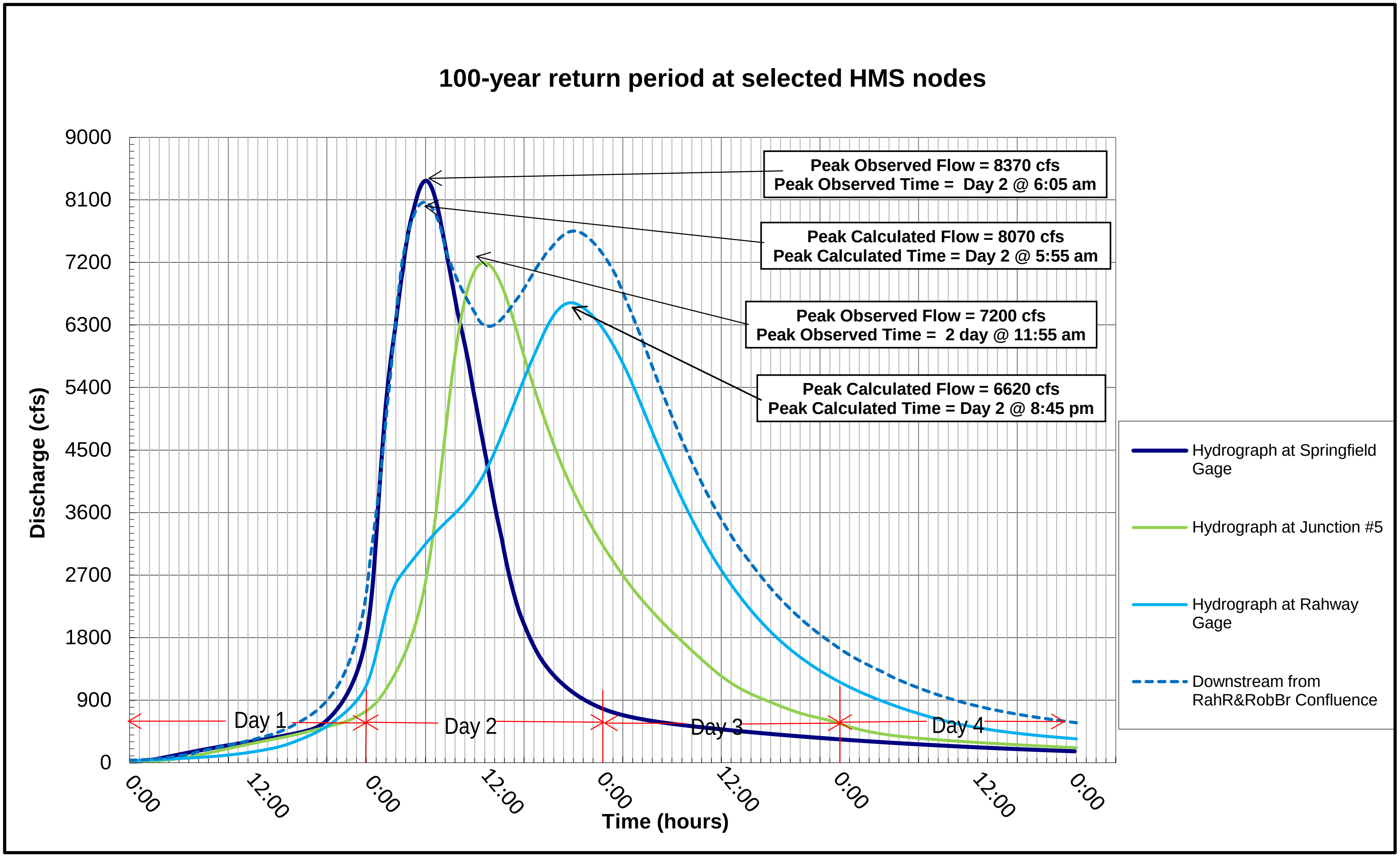

FIGURE 20: HYPOTHETICAL FLOOD (100-YEAR) AT SELECTED NODES ALONG THE RAHWAY RIVER FOR THE RAHWAY PROJECT AREA

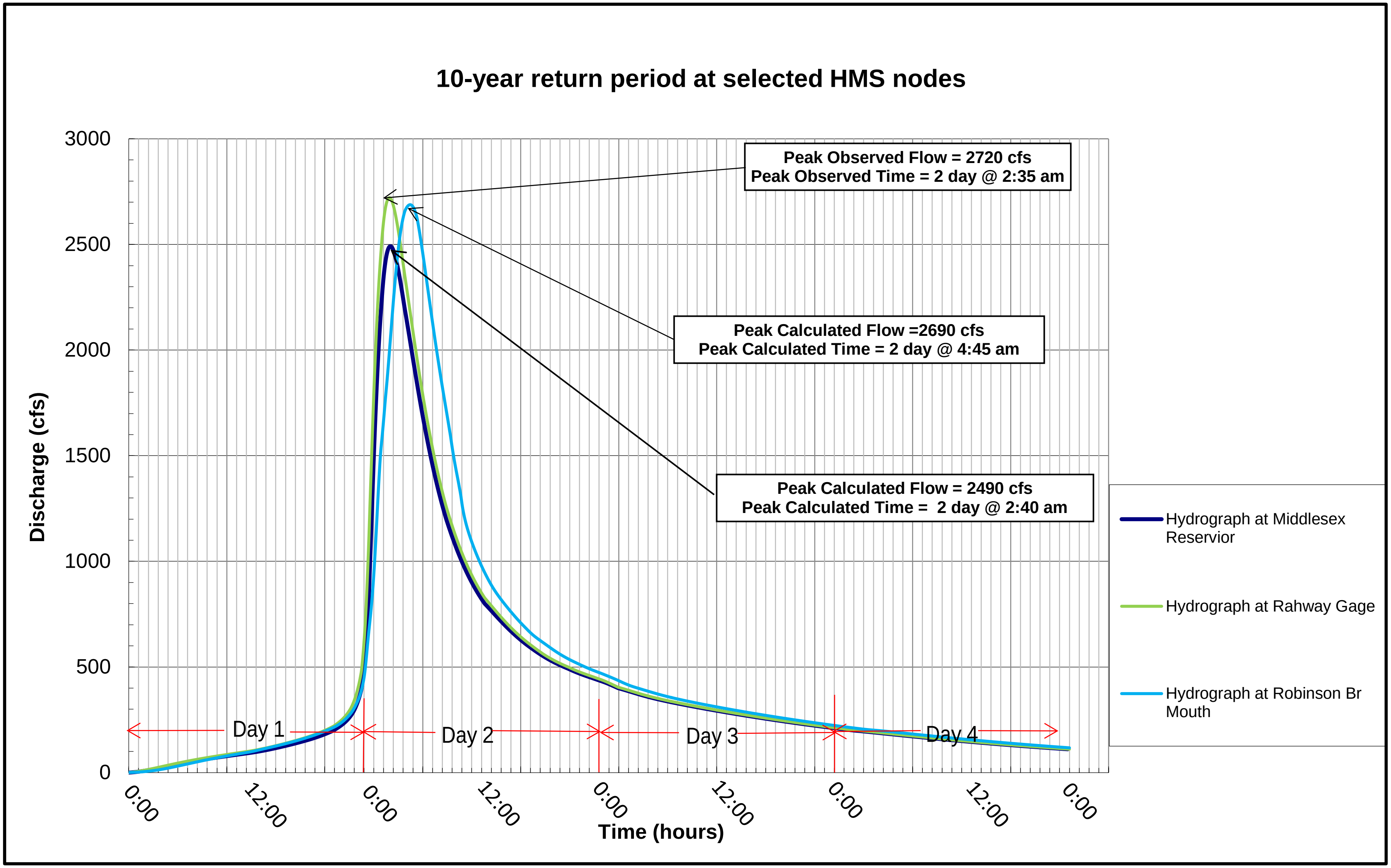

FIGURE 21: HYPOTHETICAL FLOOD (10-YEAR) AT SELECTED NODES ALONG ROBINSON BRANCH FOR THE RAHWAY PROJECT AREA

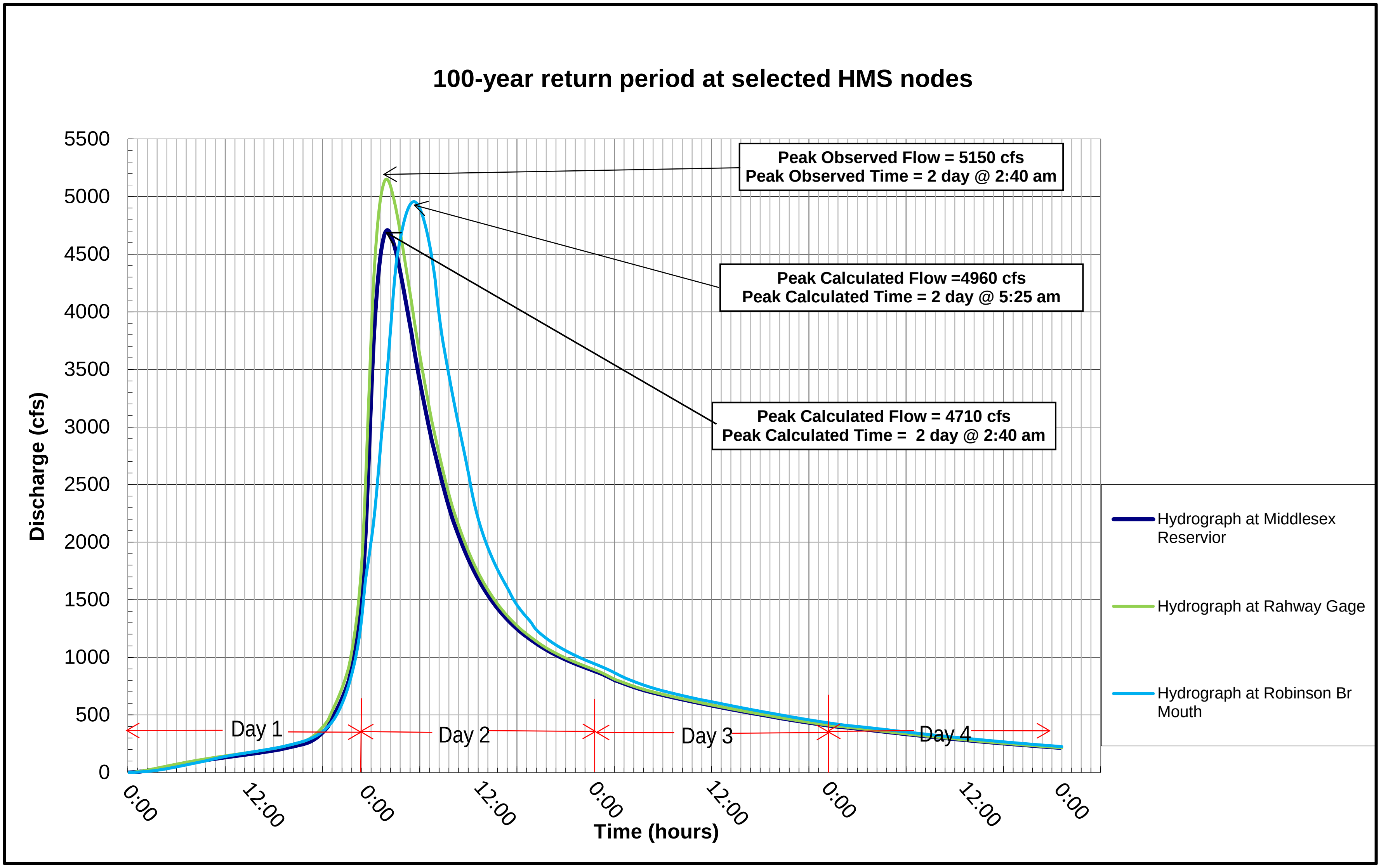

FIGURE 22: HYPOTHETICAL FLOOD (100-YEAR) AT SELECTED NODES ALONG ROBINSON BRANCH FOR THE RAHWAY PROJECT AREA

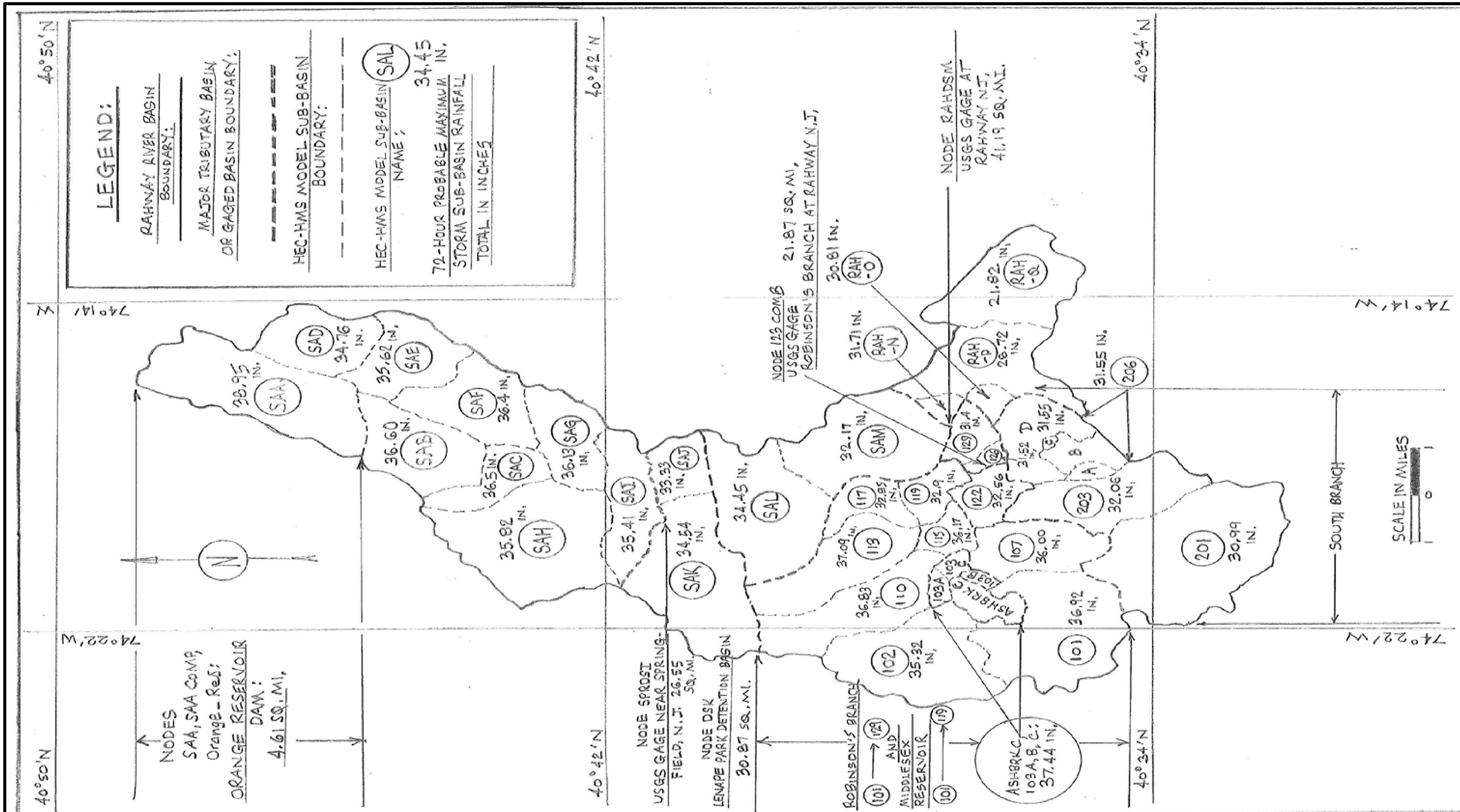

FIGURE 23: SAMPLE PMS ELLIPSOID OVER THE RAHWAY WATERSHED BASED ON THE "FOUR CENTERING" RUN

Draft Appendix CII

Hydraulics

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

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1.0 INTRODUCTION

1.1 Area of Study

The Rahway River Basin is located in northeastern New Jersey. It lies within the metropolitan area of New York City and occupies approximately 15 percent of Essex County, 35 percent of Union County, and 10 percent of Middlesex County. The basin is approximately 83.3 square miles (53,300 acres) in area. Its greatest width is approximately 10 miles in the east-west direction, from the City of Linden to the City of Plainfield. Its greatest length is approximately 18 miles in a north–south direction, from West Orange to Metuchen. A map of the Rahway River Study area and the municipalities that it lies within, is shown on Figure 1.

1.2 Present Flooding Problems

Periodic storms have caused severe fluvial flooding along the Rahway River. There are two main areas with high flood risk, the Township of Cranford and the Robinsons Branch in Rahway. Flooding along the Rahway River at Cranford is caused by low channel capacity, constrictions of several bridges and dams along the river and two 90 degree bends forming a “U” turn at the Springfield Ave. just upstream of the center of the Township. The flood waters backup from the main Cranford area into the area of Lenape Park Detention Basin and Kenilworth Township. In City of Rahway at Robinson’s Branch the high risk of flooding is due to low channel capacity, the constrictions of several bridges, and the backwater from the main stem of the Rahway River, which is independent of the hydraulic conditions in the Robinson’s Branch.

1.3 Objective

The objective of this study is to identify the most cost effective mean of managing the risk of flooding in the most affected areas of the Rahway River basin, while meeting safety, environmental and cultural requirements. The flood risk management concepts included in this study are: channel modification, bridge replacement, creation and/or modification of hydraulic structures (i.e. dam, levee) and non-structural plans.

2.0 RAHWAY RIVER DESCRIPTION

2.1 General

The head waters of the Rahway River start at the East and West Branch of the Rahway River. The head water for the East Branch is located in the vicinity of City of Orange, flowing downstream through South Orange and Maplewood Townships. The head water for the West Branch is located in the vicinity of West Orange, flowing downstream through the South Mountain Reservation into the Township of Millburn. The Branches merge into the main stem Rahway River at Springfield and Union Township and flows in a north-south direction for approximately 2.5 miles from I-78 to Route 22. From this point it flows directly into Cranford, Winfield and Clark Township, meeting with the Robinson's Branch at Rahway. Approximately half a mile downstream it meets the South Branch and keep flowing downstream meeting Linden and Carteret Townships.

The channel side slopes are moderate and vary from 5 to 15 ft. in height. The channel bottom in the Rahway River has a variable slope, approximately 2.0 ft./mile at the tidal influenced area, 8.0 ft./mile from Robinson's Branch to Cranford and 3.0 ft./mile from Cranford to the confluence between the East and West Branches. The West Branch of the Rahway River by the Township of Millburn and the South Mountain Reservation the slope becomes steep, approximately 55 f./mile. In the affected areas of the Robinson's Branch the slope of the channel is approximately 10 ft./mile. The width of the channel at the banks varies in width from 30 to 40 ft. in the East and West Branches to 50 to 60 ft. just downstream of Route 22 to approximately 30 to 40 ft. through the Lenape and Nomahegan Parks (by Cranford Township), widening to 50 to 70 ft. near the confluence with Robinson's Branch.

Overall, although is a highly develop sub-burb of New Jersey, the banks of the river are densely cover by trees and shrubs. Areas adjacent to the river are mostly protected by the non-federal sponsor (NJDEP) and the Green and Blue Acres Program. The debris produced by the high vegetation in combination with the quick rising flows results in floods in many areas of the Rahway River Basin.

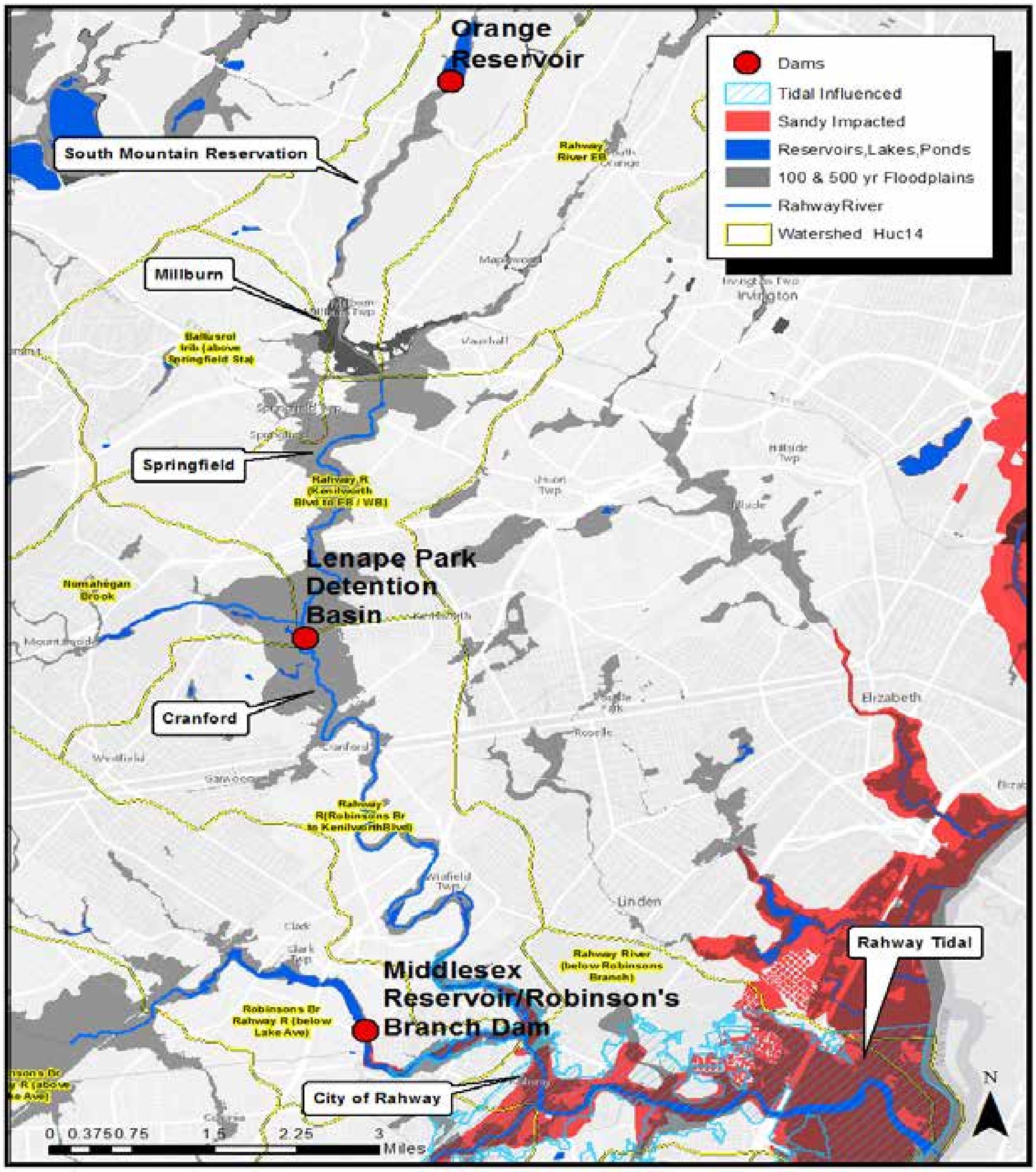


Figure 1: Rahway River Study Area and communities.

2.2 Flood Prone Areas

The Rahway River in the Township of Cranford and Robinson's Branch at Rahway begin to experience fluvial flooding at and above the 10% chance of annual exceedance (10-yr) event. See Figure 17 for inundation of the Cranford area.

At this stage the low-lying area between Park Dr. and Springfield Ave. near the Nomahegan Park Back experiences flooding due to back water from a tributary of the Rahway River and some street flood upstream of Hansel Dam. For peak flows between the 10% chance of annual exceedance (10-yr) and the 4% chance of annual exceedance (25-yr) events, water surface elevations (WSEs) in the Rahway River overtop the Nomahegan Park levees. Although there are some inconsistencies in the top elevation of the levees, both sides of the levee system can contain approximately the same event. For storm events above the 4% chance of annual exceedance (25-yr), the stage of the Rahway River waters starts producing floods in the following areas:

1. Kenilworth residential area due to backwater caused by the constrictions of the Kenilworth Blvd. Bridge.
2. At the right overbank between Willow St. and Brookside Place, near Cranford High School.
3. At the left and right sides overbanks and behind the existing levee system, the residential area at the residential area surrounding Riverside Dr., Brookdale Rd., Edgewood Rd., Glenwood Rd., Summit Rd., Edgar Ave., Franklin Ave., Balmiere Pkwy. and Doering Way.
4. And the commercial area surrounding Chestnut St.

Floods above the 20% chance of annual exceedance (5-yr) produce damages in the low lying areas of Robinson's Branch, and on the Rahway River between its confluences with Robinson's and South Branches. Other areas upstream, in the Robinson's Branch between Maple Ave. and St. Georges, start suffering damages at the 4% chance of annual exceedance (25-yr) events.

2.3 Existing and Proposed Hydraulic Features Along the Rahway River at Cranford

Some areas along the Rahway River have seen a decrease in flood risk due to improvements implemented through the years. These are several of the existing federal and non-federal projects in place:

1. Nomahegan levee system: The Nomahegan Park levee system is located on both sides of the banks in the Rahway River; protecting a commonly flooded

residential area in Cranford. The left and right bank levees are approximately 1,800 ft. and 4,000 ft. long respectively. The levees are approximately 4 to 6 ft. high and have approximately a 6 ft. top width. There is also a flood reduction plan developed by the Township of Cranford in regards to the levees. It includes the construction of interior drainage stormwater pipes, pump stations for the east and west side of the existing levees, improvements to the stormwater sewer system and improvements of the existing levees. The Township plans are divided into the following phases:

Phase 1: Drainage swale approximately 500ft north of Belmont Ave. and express stormwater sewer pipeline, constructed in 2006.

Phase 2: Riverside drive stormwater pump station, and north and south gravity storm sewer interconnection, constructed in 2008.

Phase 3 & 4: Improvements to the Nomahegan Park and residential area existing levee system, currently on hold.

Phase 5: Park Ave. pumping station, Penn Rd. stormwater sewer pipeline and local collector system, currently on hold.

2. Lenape Park Dam: The dam creates dry detention area with a capacity of approximately 2100 acre-ft. at the top of the embankments, enough to hold a 1% chance of annual exceedance events (100-yr) without flood without overtopping. The secondary, or emergency, spillway is designed to overflow for the 4% chance of annual exceedance event (25-yr). The dam consist of a concrete spillway 100 ft. long and approximately 25 ft. high and earthen embankments approximately 10,000 ft. long with an approximately 10 ft. top width and one vertical to thee horizontal (1V:3H) side slopes. The right dam embankments located in the township of Cranford and Westfield are fairly well maintained. By contrast, the left embankment in Kenilworth, has a considerable amount of vegetation and trees growing on top.

3. Springfield Levees: The levee system is located in the right bank of the Rahway River in Springfield Township. The system is divided into three (3) segment with varying top elevations. The north segment is approximately 1,560 long with a variable top elevation between 88.5 and 90 ft. NAVD 88. The middle segment is approximately 1,500 ft. long with a top elevation of approximately 86 ft. NAVD 88. This segment has the lowest top elevation of the three, with the smallest top width and is lacking in maintenance. The most downstream segment is approximately 1,900 ft. long and has with a top elevation of approximately 88 ft.

NAVD 88. The upstream end of the system is located at the Springfield Ave. Bridge (just downstream of I-78) and ends just upstream of the confluence between the Rahway River and Van Winkles Brook.

4. USACE South Branch Flood Control Project of 1968. This is a combination of levees, floodwalls and channel modification. There are levees along the right bank of the Rahway River by the City of Rahway and floodwalls and channel modification along the river and left bank in South Branch. This system was constructed in the 1970's, it is fairly well maintained. This levee system is periodically inspected by the USACE.

3.0 HYDRAULC BASIS OF DESIGN

3.1 Model Development

The hydraulic analysis of the Rahway River documented herein consists of a combination of steady and unsteady state numerical modelling using the Hydrologic Engineering Center (HEC) River Analysis System (HEC-RAS) software. The first analysis of the Rahway River was performed with HEC-RAS version 4.2. The geo-spatial boundaries of the model are: to the north from West Orange by the Orange reservoir and to the south in Cranford township. This combination of steady and unsteady flow models was used to develop the without and with project conditions for this area only. Alternatives that included modification and/or a new reservoir were analyzed with the Hydrologic Modeling System (HEC-HMS) hydrologic model, and later input to the HEC-RAS model as discharge inflow hydrographs.

This hydraulic model was later improved by conversion to a complete unsteady state model. It was then extended to include the West Branch of the Rahway River, the main stem from Cranford to Arthur Kill and the tributaries Robinson's Branch and South Branch. This model was created using HEC-RAS version 5.0. This later version was used for the without and with project conditions of Robinson's Branch.

The first model geometry was created using surveyed topographic data for the area of Cranford and 2007 LiDAR of New Jersey for the upstream areas of Springfield and Millburn. In Cranford the channel cross sections were placed no more than 300 ft. apart, supplemented with 2 ft. contour topographic map from June 2009 to create overbanks cross sections. The 2009 topographic mapping was developed by Roger Surveying, PLLC. and included the survey of utilities, bridges and weirs. For the areas of Millburn and Springfield, channel cross sections, bridges and weirs were obtained from the FEMA

– Flood Insurance Study (FIS) HEC-RAS model. The FEMA channel cross section were supplemented with LiDAR to create the overbanks cross sections.

The improved second model geometry, created for the extended Rahway River model, use additional surveyed topographic mapping for Robison's Branch, developed in 2012 by McKim & Creed. This survey also included channel cross sections (which were placed no more than 300 ft. apart), utilities, bridges and weirs. Additional LiDAR and FEMA – FIS data were used to develop the geometry for the tidal portions of the Rahway River, South Branch and Upper Robinson's Branch.

3.2 Model Calibration and Validation

The HEC-RAS model was calibrated with data from two floods. The nor'easter flood of April 15-19 2007 was used for the first model in the areas of Cranford and Springfield. The August 27-31 2011 flood, caused by Tropical Storm Irene, was used for the second improved model which included the Robinson's Branch. A hydrologic analysis of the Rahway River Basin performed HEC-HMS software provided discharge hydrographs for the April 2007 nor'easter and Tropical Storm Irene floods. The flows and hydrographs computed by the HEC-HMS model of the Rahway River Basin were referenced to cross sections and locations in the HEC-RAS riverine geometry using the HEC-HMS hydrologic nodal diagram of the Rahway River Basin.

In the first step of calibration; visual observations, Arc-GIS land cover and aerial photographs, were used to characterize the initial Manning's n-value. The overbanks varied from open spaces and parking lots to areas with high density vegetation or structures. Initial n-values were set between 0.025 and 0.045 for the channel, and overbank n-values were estimated to range between 0.025 and 1.5. Manning's n-values of 1.5 in the geometry file implies areas with no flow and high obstructions. Ineffective flow areas were identified in the overbanks, at bridges and bends to better represent the effects of structures and topography on flow conveyance. Contraction and expansion coefficients for the open channel sections were initially set at 0.1 and 0.3, and for bridge sections, at 0.3 and 0.5.

In the second step of calibration, field surveys provided a total of 26 high water marks (HWMs) for the Township of Cranford and 16 HWMs for the Robinson's Branch. Further adjustments to Manning's n-values, contraction and expansion coefficients, weir coefficients, ineffective flow areas, and other loss coefficients were made in order to reproduce the WSEs to within ±0.5 ft. of the observed HWMs. Tables 1 and 2 show the HWMs elevations for the April 2007 nor'easter and TS Irene, as well as the location and computed WSEs. Figures 2 thru 5 are the HEC-RAS WSEs calibration profiles for April 2007 and Irene storm events respectively.

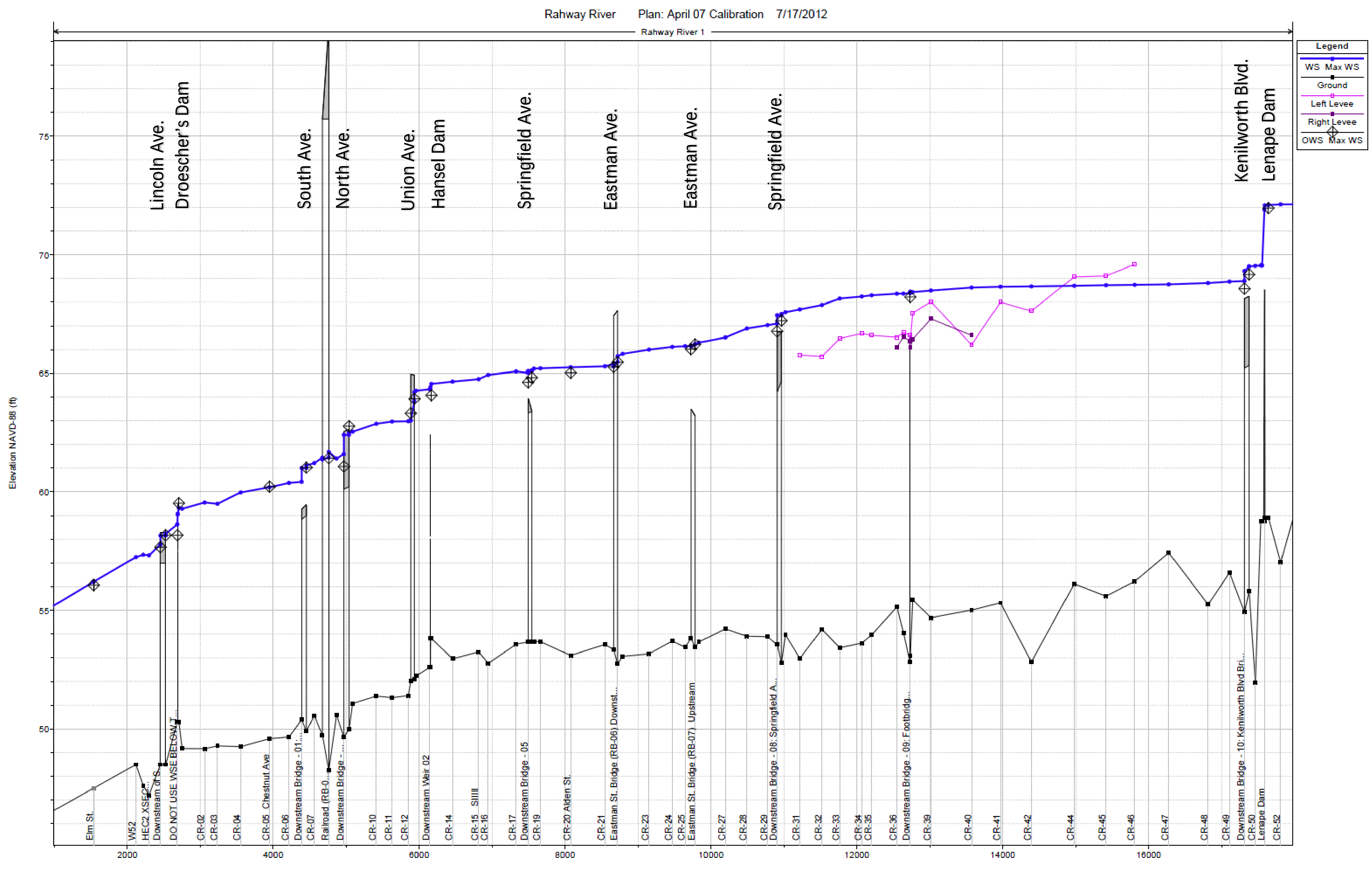
Table 1: TS Irene peak observed HWMs and HEC-RAS calibration.

River Reach	HEC-STA	Computed WSE (ft., NAVD88)	HWM Elevation (ft., NAVD88)	Difference (ft.)	Location
Robinson's Branch	8847.78	25.41	25.50	-0.09	***01396000 Robinson's Branch***
Robinson's Branch	6724.74	19.96	19.82	0.15	644 Maple
Robinson's Branch	5922.51	19.85	19.72	0.13	941 JEFFERSON
Robinson's Branch	5902.69	19.65	19.76	-0.11	Jeff-Elm-Bouman
Robinson's Branch	5282.55	19.28	19.58	-0.30	633 Bouman
Robinson's Branch	4008.99	18.78	18.99	-0.21	1229 St. Georges
Robinson's Branch	2583.05	18.29	18.30	-0.01	1452 Church
Robinson's Branch	1950.95	17.10	17.00	0.10	360 Hamilton
Robinson's Branch	962.53	16.80	16.80	0.00	277 Hamilton
Robinson's Branch	777.87	16.10	15.91	0.19	Irving 1653
Millburn&Springf	82722.00	76.61	76.02	0.59	***01394500 Springfield***
Cranford&Clark	75673.94	71.15	72.55	-1.40	***01394620 Kenilworth***
Cranford&Clark	33116.94	19.59	19.81	-0.22	***01395000 Rahway***
Cranford&Clark	28743.80	15.03	14.98	0.05	182 Grand
Rahway	27995.02	14.49	14.43	0.06	***Confluence***
Rahway	26897.93	11.52	11.60	-0.08	Monroe Ave.

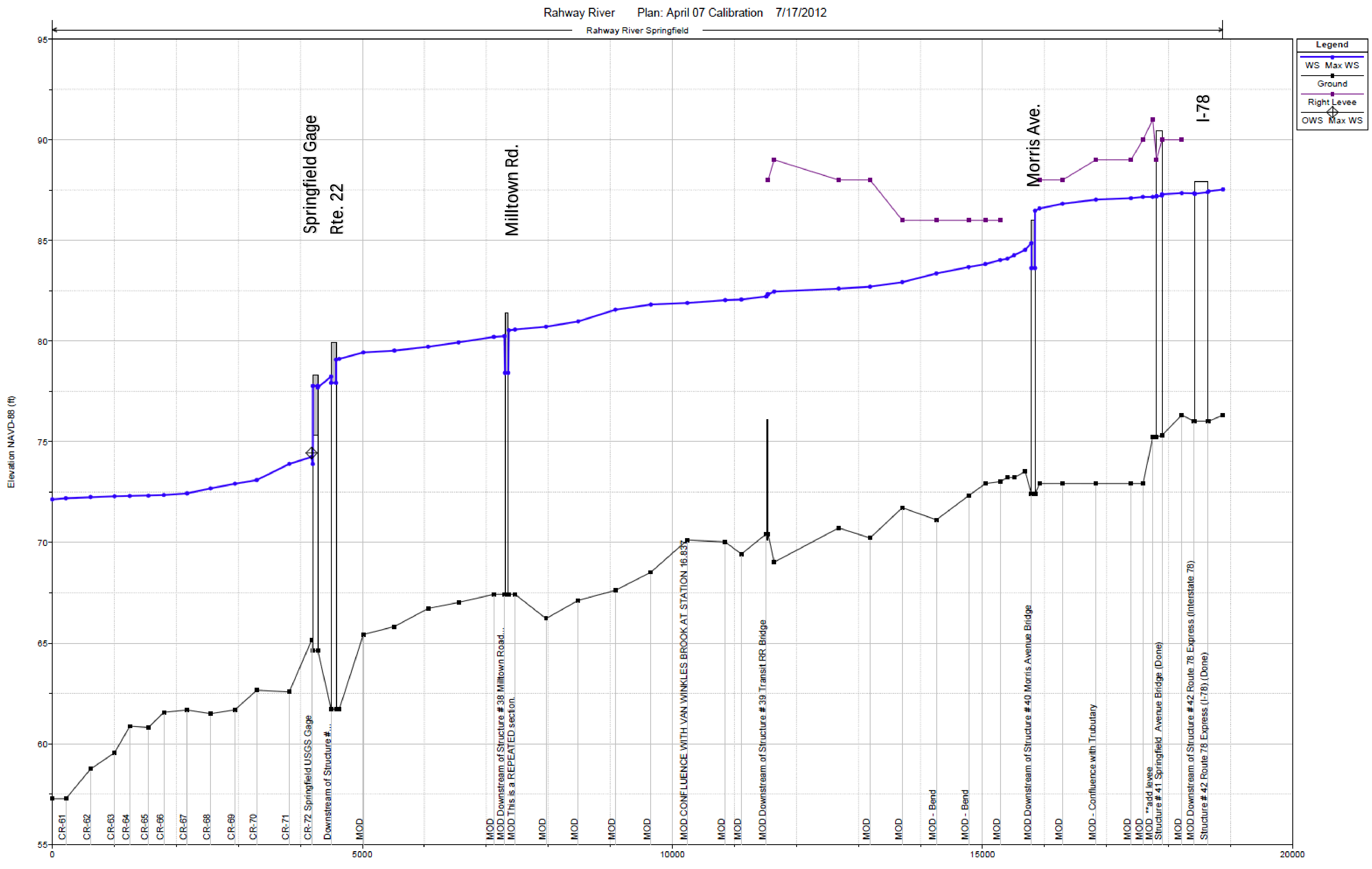
Table 2: April 15, 2007 peak observed HWMs and HEC-RAS calibration.

River Reach	HEC-STA	HEC Calibration WSE (ft., NAVD88)	HWM Elevation (ft., NAVD88)	Difference (ft.)	Location
Springfield	22865.14	74.24	74.44	-0.20	***01394500 Springfield***
Rahway River 1	15541.78	72.1	71.97	0.13	Lenape Park Dam Upstream
Rahway River 1	15289.71	69.51	69.17	0.34	Kenilworth Blvd. Upstream
Rahway River 1	15220.78	68.89	68.57	0.32	Kenilworth Blvd. Downstream
Rahway River 1	10200.53	68.44	68.22	0.22	Footbridge
Rahway River 1	8356.55	67.45	67.22	0.23	Springfield Ave. Upstream
Rahway River 1	8239.93	67.1	66.77	0.33	Springfield Ave. Downstream
Rahway River 1	7093.82	66.22	66.22	0.00	Eastman St. Upstream
Rahway River 1	7035.95	66.16	66.02	0.14	Eastman St. Downstream
Rahway River 1	6034.42	65.79	65.47	0.32	Eastman St. Upstream
Rahway River 1	5979.88	65.39	65.27	0.12	Eastman St. Downstream
Rahway River 1	5390.42	65.25	65.02	0.23	Alden St.
Rahway River 1	4857.53	65.1	64.82	0.28	Springfield Ave. Upstream
Rahway River 1	4807.32	65.02	64.62	0.40	Springfield Ave. Downstream

Rahway River 1	3481.18	64.55	64.07	0.48	Hansel's Dam Upstream
Rahway River 1	3249.36	64.2	63.92	0.28	Union Ave. N Upstream
Rahway River 1	3201.12	63.01	63.32	-0.31	Union Ave. N Downstream
Rahway River 1	2351.8	62.5	62.77	-0.27	North Ave. E Upstream
Rahway River 1	2882.7	61.59	61.07	0.52	North Ave. E Downstream
Rahway River 1	2076.15	61.88	61.42	0.46	Railroad Bridge Upstream
Rahway River 1	1769.88	61	61.02	-0.02	South Ave. E Upstream
Rahway River 1	1265.99	60.2	60.22	-0.02	Chestnut St.
Rahway River 1	20.6	59.31	59.52	-0.21	Droescher's Dam Upstream
Rahway River 1	11.46	58.24	58.17	0.07	Lincoln Ave. Bridge Upstream
Rahway River 1	11.45	57.78	57.67	0.11	Lincoln Ave. Bridge Downstream
Rahway River 1	11.319*	56.21	56.07	0.14	940 ft. Below Lincoln Ave.



1
2 Figure 2: Computed water surface profile and observed HWMs for the April 2007 event in the Rahway River at Cranford Township.



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4
Figure 3: Computed water surface profile and observed HWMs for the April 2007 event in the Rahway River at Cranford and Springfield Townships.

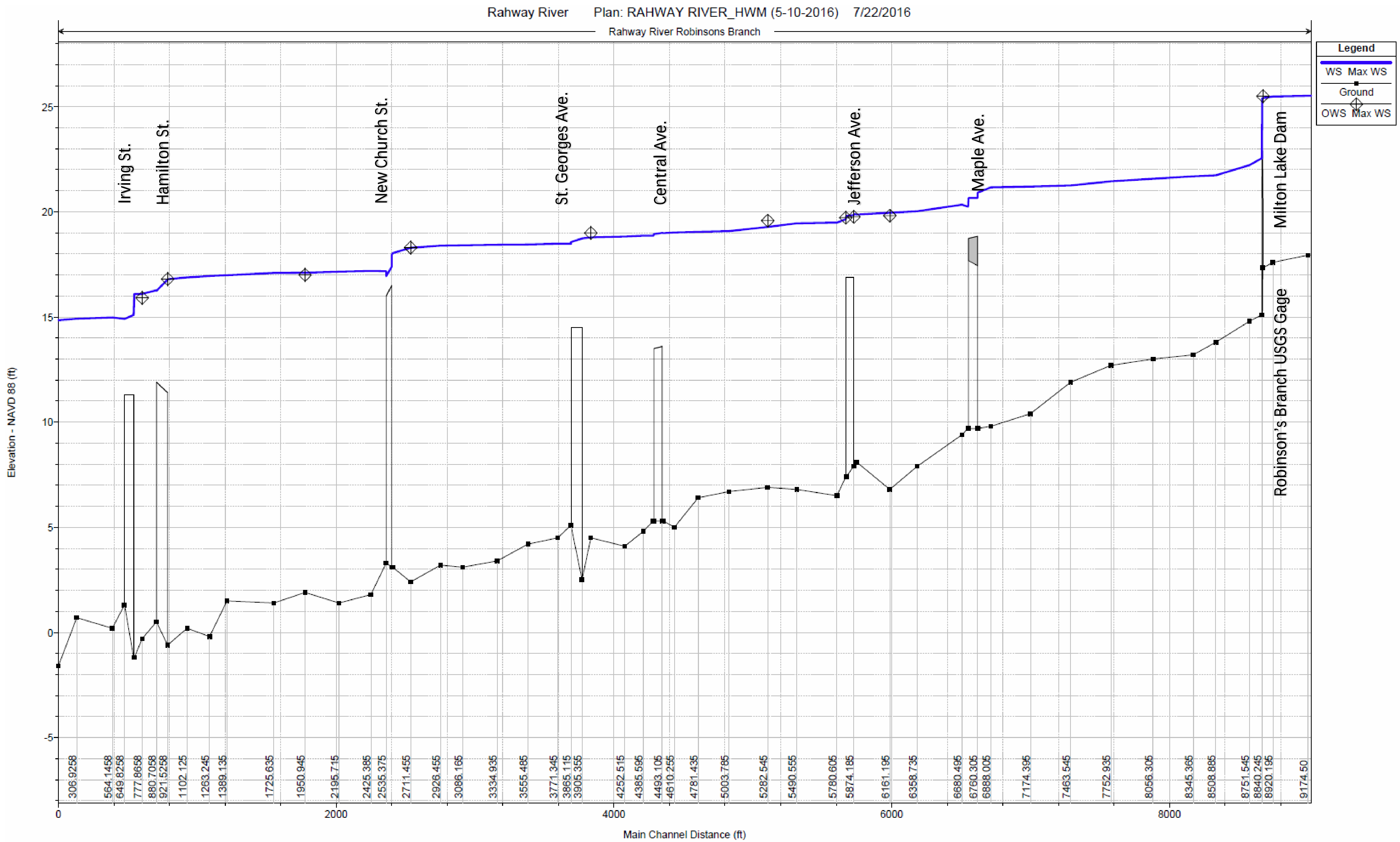

Figure 4: Computed water surface profile and observed HWMs for TS Irene in Robinson's Branch.

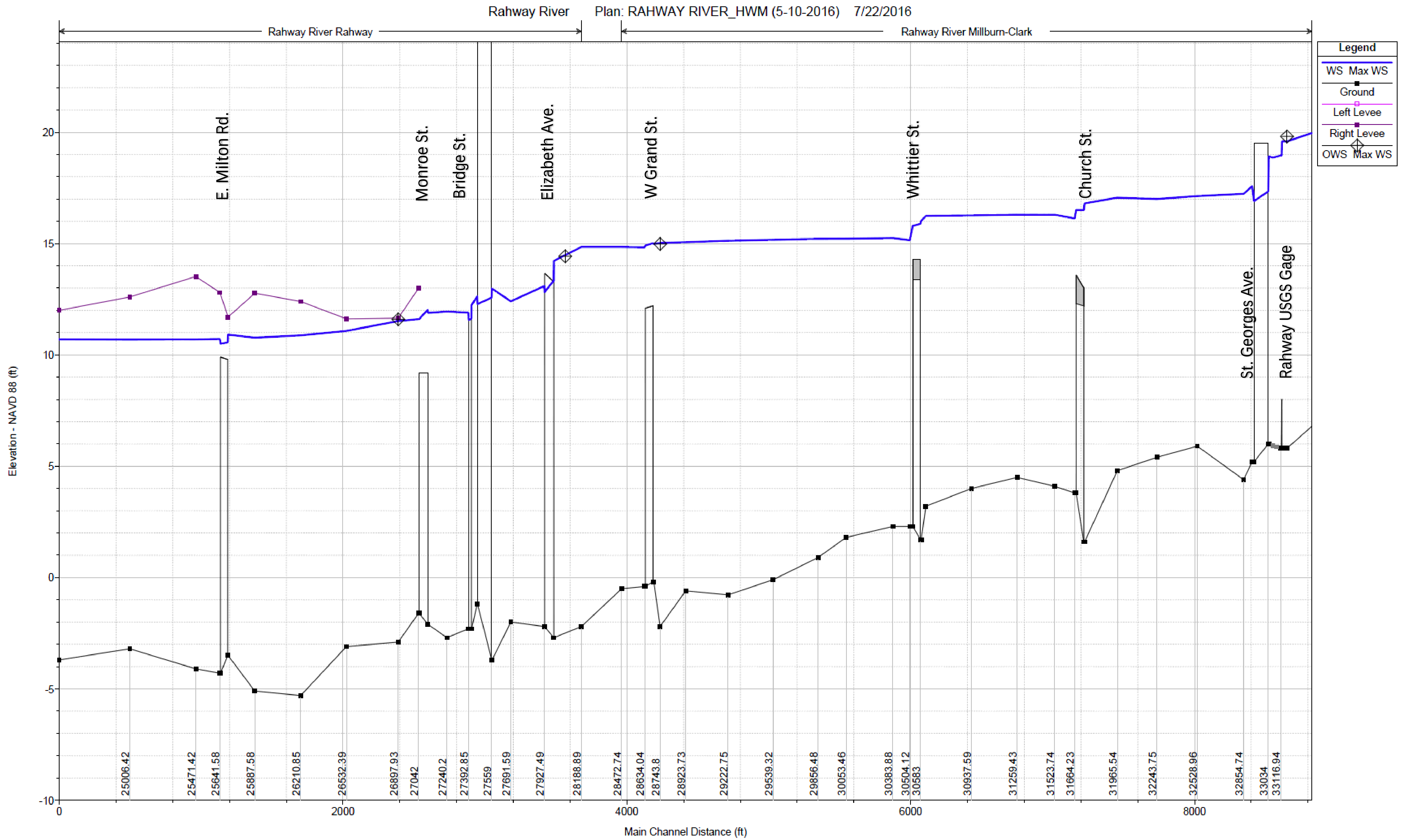

Figure 5: Computed water surface profile and observed HWMs for TS Irene in the Rahway River, from the confluence with the South Branch to the USGS gage at Rahway.

The next step of the calibrating process is to replicate the USGS rating curves (RC) and observed annual peak stages at the USGS gages. This allowed an accurate determination of WSEs for a wide range of flows. This additional calibration step was only performed for the unsteady, or second, hydraulic model. The calibration and comparison between HEC-RAS computed RC, the USGS RC and the observed annual peak flows can be seen in Figures 6 thru 9. In these figures the blue line is represent the HEC-RAS computed RC, the black line represents the USGS RC and the dots represent the observed annual peak flows. All elevations for the RC and hydrographs are in NAVD 88. Most of the computed RC are within ±0.5 ft. of the USGS RC, except at the Rahway and Millburn gages. The HEC-RAS-computed rating curves differ from the USGS rating curves at their upper ends for several reasons. First, the USGS rating curves are subject to error at higher flows because very few flow measurements are made, and are available for, large floods. Second, overbank flow is much harder to measure and predict than channel flow. Third, USGS rating curves are extrapolated to high flow values from orders of magnitude lower flow observations. Another factor is the tidal influence on the Rahway River at Rahway USGS stream gage. The unsteady HEC-RAS model was further validated by simulating and reproducing TS Irene stage hydrographs at USGS gage, shown in Figures 10 thru 12. In these figures the blue line is represent the HEC-RAS computed stage hydrograph, the black line represents the USGS RC and the green line represent the observed flows hydrographs. All hydrographs elevations are in NAVD 88. The compute stage and flow hydrographs replicated the observed stage and flow hydrographs for the gages at Springfield, and on Robinson's Branch. During TS Irene the Rahway gage was submerged by the coastal surge and the gage records are discontinuous, therefore the TS Irene stage and flow hydrographs for the Rahway gage are not reliable for this event.

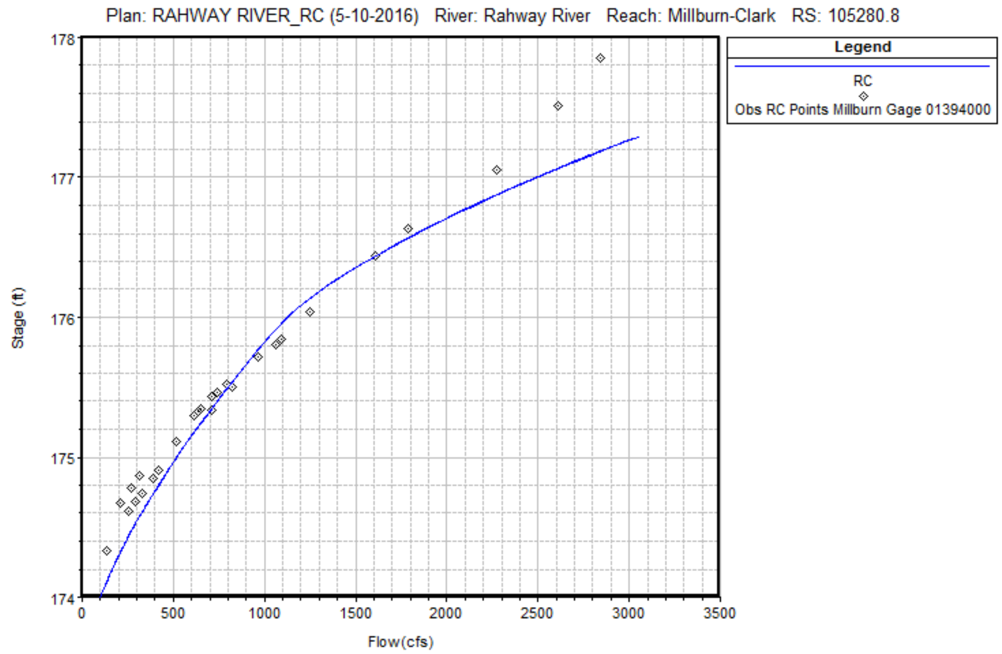

Figure 6: Observed annual peaks flows for USGS gage No.01394000 at Millburn.

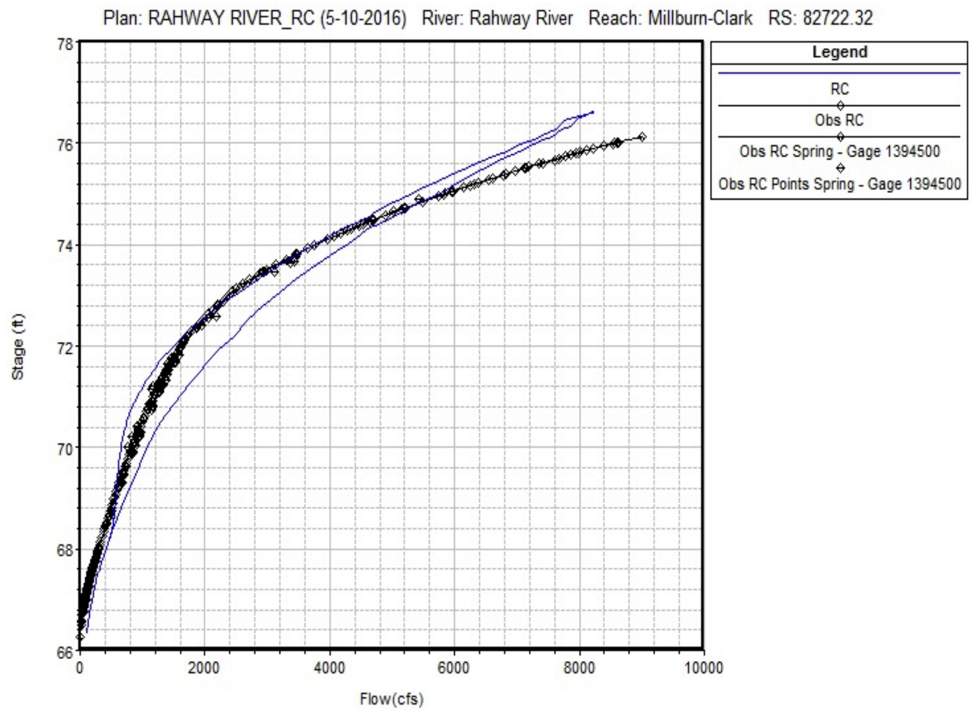

Figure 7: Observed annual peak flows and RC for USGS gage No. 01394500 at Springfield.

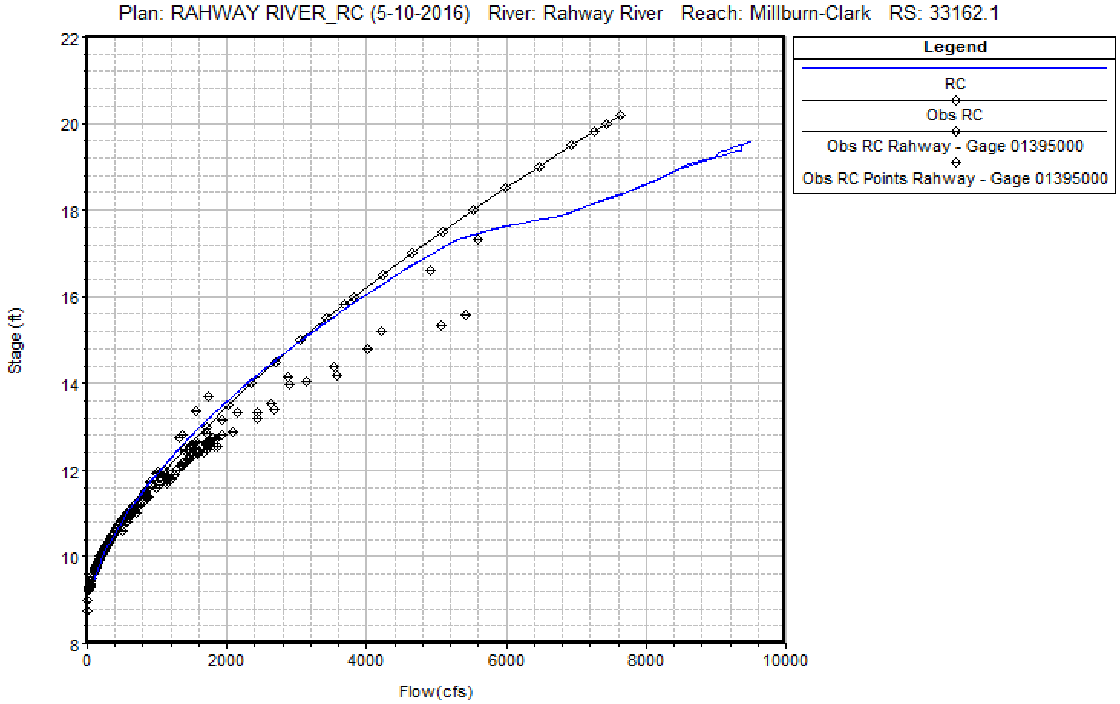

Figure 8: Observed annual peaks flow and RC for USGS No. gage 01395000 at Rahway.

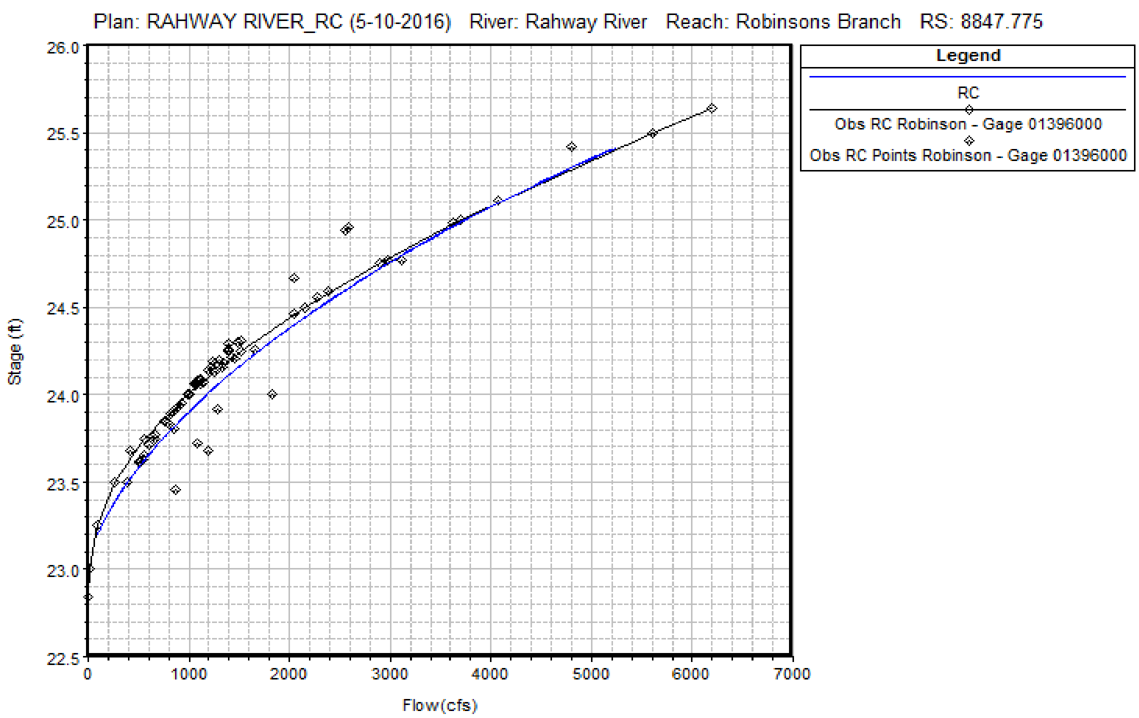

Figure 9: Observed annual peak flows and RC for USGS gage No.01396000 at Robinson's Branch.

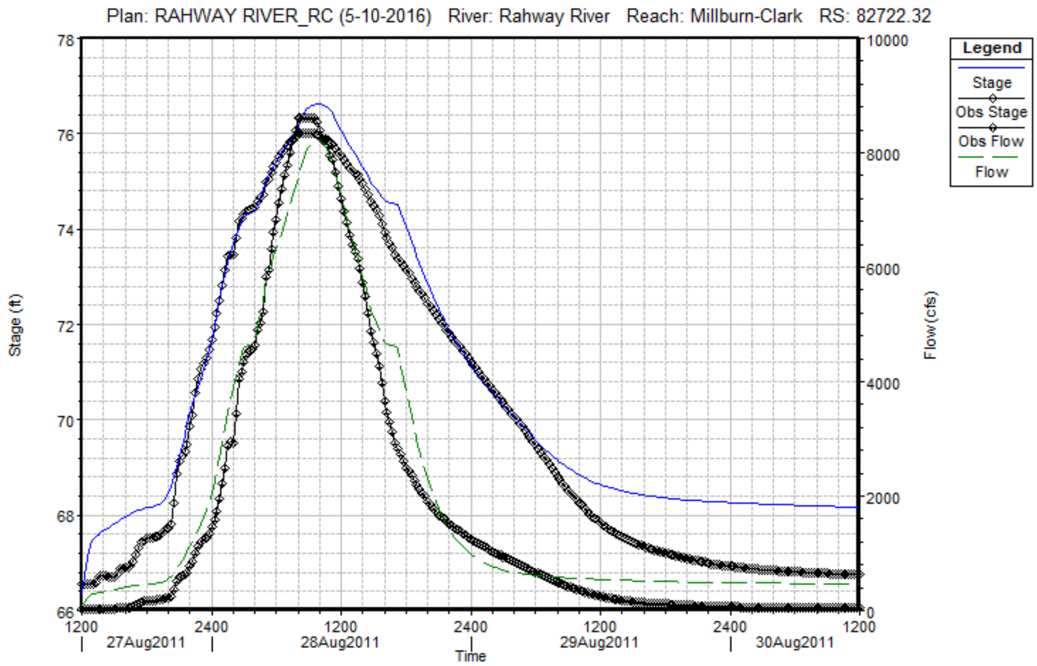

Figure 10: Observed and computed stage and flow hydrograph for USGS gage No.01394500 at Springfield.

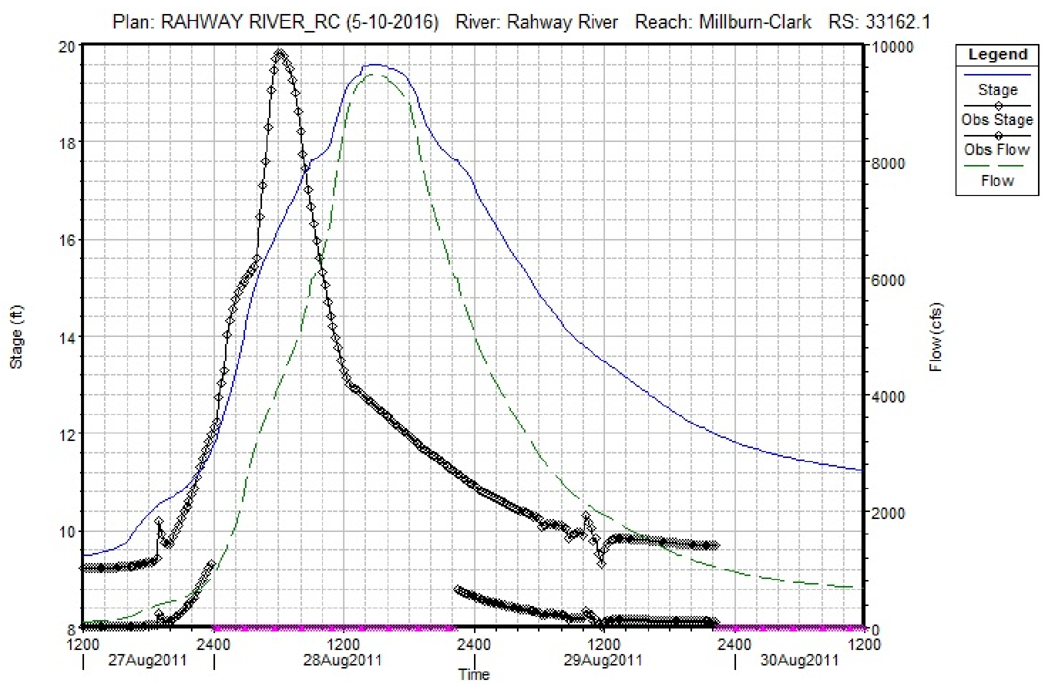

Figure 11: Observed and computed stage and flow hydrograph at USGS No. 01395000 at Rahway.

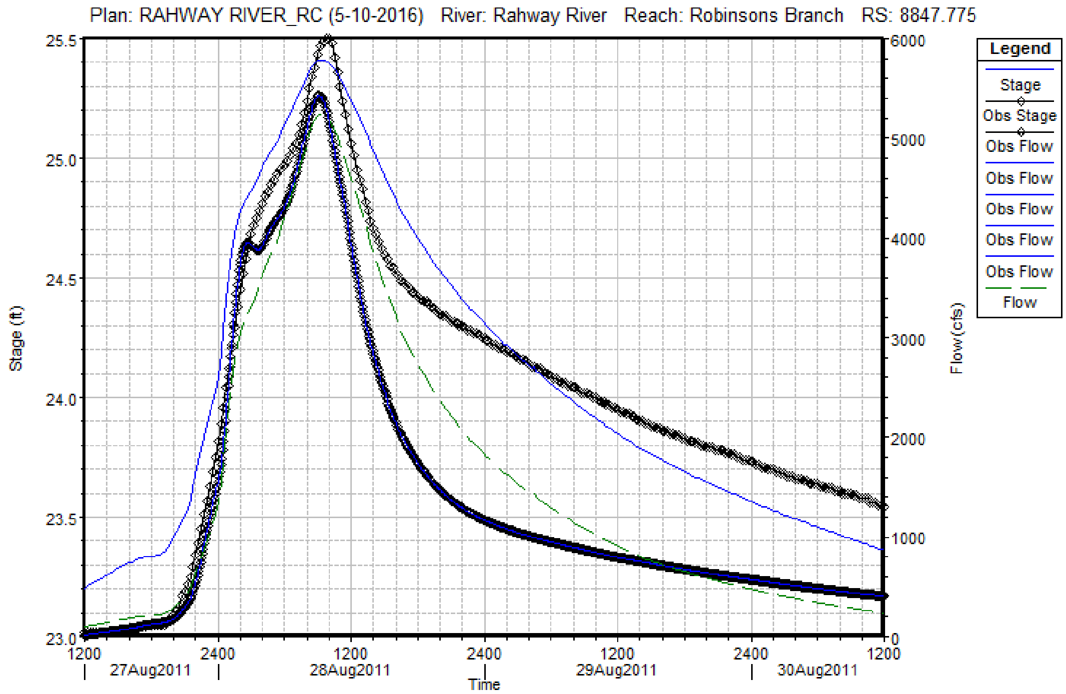

Figure 12: Observed and computed stage and flow hydrographS at USGS No. 01396000 at Robinson's Branch.

3.3 Tidal Influenced areas and Fluvial/Tidal Joint Probability

3.3.1 Boundary Conditions

In order to run a hydraulic model of the Rahway River with a set of hypothetical events, a starting elevation or boundary condition had to be established for the mouth of the River. Since the Rahway River flows into the Arthur Kill (a tidal strait), it was necessary to perform a tidal-fluvial correlation to establish the backwater elevations that may occur due to tide and surge during a typical fluvial event. In this analysis, both the tidal gage at Bergen Point (ID: 8519483) and the fluvial gage at Rahway (USGS No. 10395000) were used to correlate harbor data with matching fluvial data. Only significant yearly fluvial events and the corresponding maximum tidal stage were used in the correlation analysis. The available simultaneous data for both gages is approximately 34 years. The results shows that there is a 99.9% probability during the 50 years project period that the tidal stages will be at or below the 20% chance of annual exceedance event (5-yr) for any given fluvial flood. In addition, the results showed that most fluvial events are coupled with tidal events below the 100% of annual exceedance events (1-yr). Figure 13 shows the frequency of significant flow events plotted with the frequency of the maximum tide for those events all at the Rahway gage.

Based on this analysis the follow tidal boundary conditions were established. The 100% annual exceedance fluvial event (1-yr) was coupled with the 100% annual exceedance tidal event (1-yr). The 50% annual exceedance fluvial event (2-yr) was coupled with the 50% annual exceedance tidal event (2-yr). All other fluvial events were coupled with the 20% chance annual exceedance tidal event (5-yr).

The North Atlantic Coast Comprehensive Study (NACCS) coastal stage-frequency curve at Rahway at mouth (node ID: 11659) was used to develop stages hydrographs for the tidal boundary condition. The shape of the tidal stage hydrographs were develop using the Bergen Point gage tide cycle characteristics. Each hypothetical stage frequency hydrographs peak was set to be coincidental to each hypothetical flow hydrograph peak at the mouth of the Rahway River. Figure 14 shows the tidal stage hydrographs boundary condition for each fluvial event.

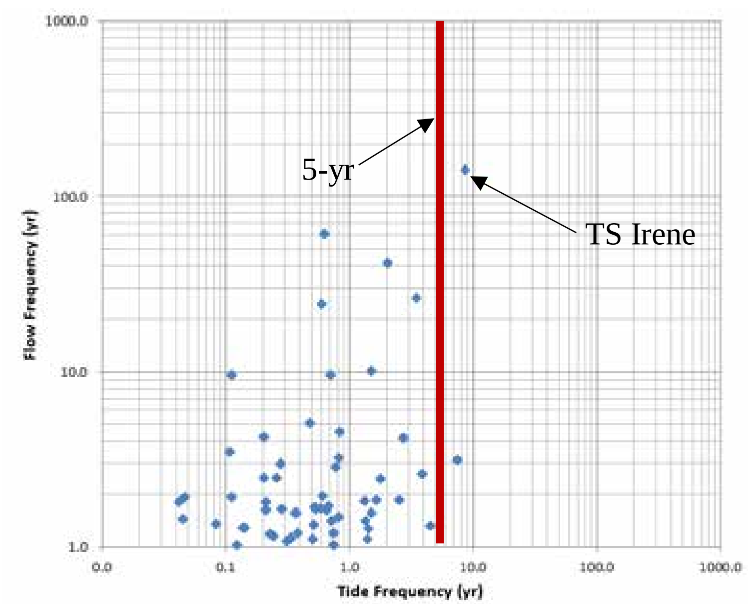

Figure 13: Significant fluvial events and the maximum tide during the event.

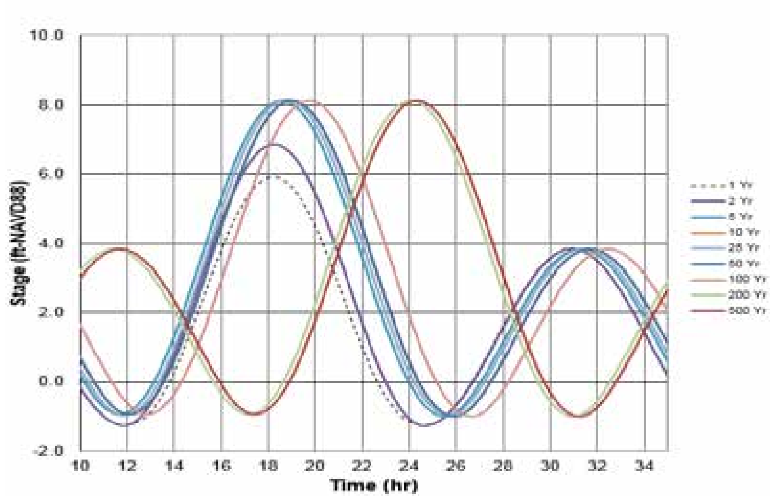

Figure 14: Stage hydrograph for each fluvial frequency event for the Rahway River at mouth.

3.3.2 Joint Stage-Probability Curves

In the lower portions of the Rahway River and the Robinson's Branch, flood stages are produced by both fluvial and tidal events. To account for the probability of a particular location to get flooded by a tidal and fluvial event, a joint probability analysis was performed. New joint fluvial and tidal stage-frequency probability curves were developed for each cross section within the tidally influence area. The new curves were computed for with and without project condition. By using joint probability curves the benefits of reducing the risk of flooding from both fluvial and coastal events was accounted for.

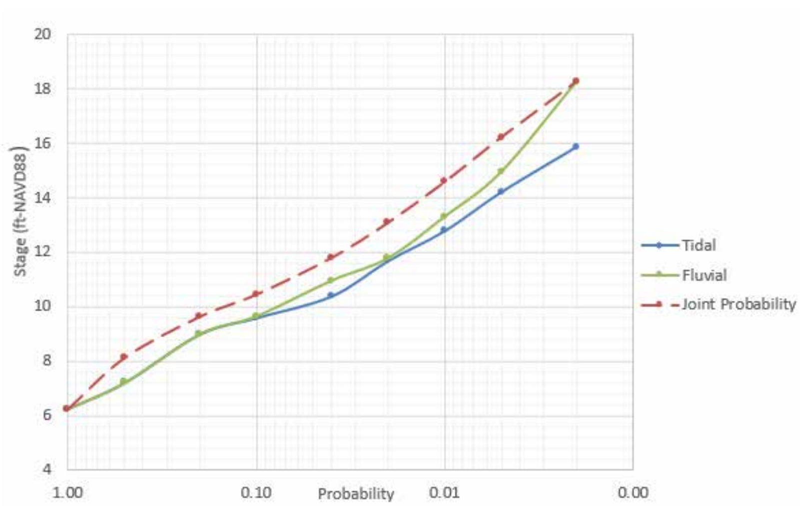

Figure 15: Joint probability curve for Robinson's Branch at mouth.

3.3.3 Sea Level Change (SLC)

Department of the Army, Engineering Regulation ER 1100-2-8162 provides guidance on incorporating the effect if projected SLC across the project life of USACE projects. Technical Letter ETL 1100-2-1 requires the use of at least three scenarios to estimate future sea levels. The USACE low rate of future SLC is based in the historic rate in the vicinity of the project area. Figure 16 shows the sea level rise trends and 33 years of data from the NOAA tide gage # 8519483 at Bergen Point, New York. This value was used to compute the expected low rate of SLC. The intermediate and high rates of future SLC are determined from the modified National Research Council (NRC -1987) eustatic sea-level change scenarios and the IPCC (2007) Types I and III respectively. The effects of vertical land movement (VLM) was also considered as a component of sea-level rise. The projected low, intermediate and high SLC scenarios are shown in Table 3.

Table 3: Projected SLC for the period of analysis of 50 years at Bergen Point #8519483, and NRC/IPCC SLC scenarios.

Year	**USACE Net SLC (ft.)**		
	Low	**Intermediate**	**High**
2015	0.00	0.00	0.00
2018	0.05	0.00	0.00
2023	0.12	0.10	0.18
2028	0.20	0.21	0.38
2033	0.27	0.32	0.60
2038	0.35	0.43	0.84
2043	0.43	0.55	1.09
2048	0.50	0.68	1.37
2053	0.58	0.80	1.66
2058	0.66	0.94	1.97
2063	0.73	1.07	2.30
2068	0.81	1.22	2.65

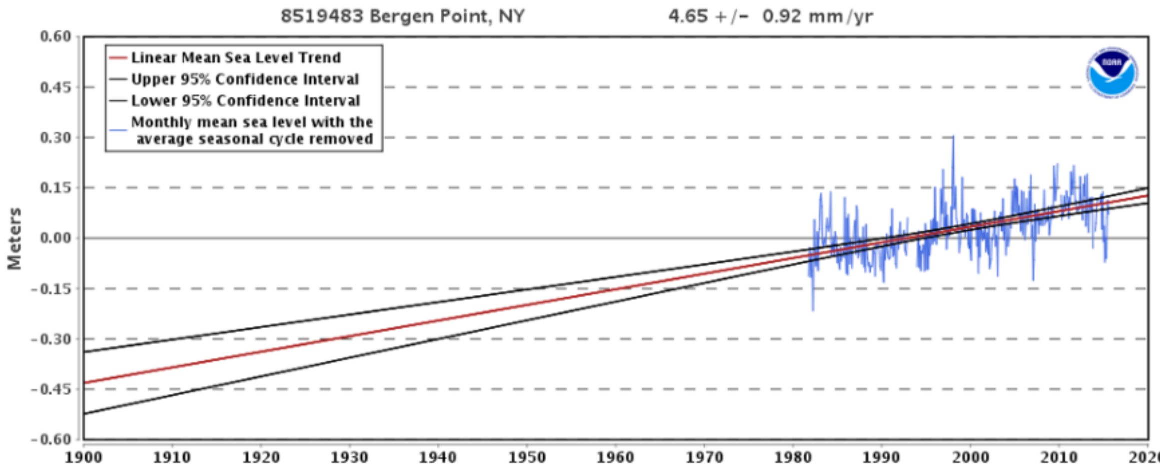

Figure 16: Sea level rise trends and monthly mean seal level at NOAA tide gage No. 8519483 at Bergen Point.

Sea level rise is expected to have impacts on direct coastal flooding along the Rahway River tidal influenced area, including impacts to properties and critical infrastructure. However, this study is limited to fluvial flood events. Future conditions, with and without project includes the historic local rate of SLR, projected 50 years into the future. All future conditions runs used tidal stage hydrograph boundary conditions that included the historic rate of SLR. The impact of SLR projections are implicit to the hydraulic and economic computation due to the use of joint stage-probability curves that were modified for future conditions to included SLR.

3.4 Present and Future Conditions - Hydraulic Profiles

3.4.1 Flow Line Computation

The calibrated HEC-RAS models of the Rahway River was used to determine the present and future, with and without project conditions WSEs for the 0.2, 0.5, 1, 2, 4, 10, 20, 50 and 100% chance of annual exceedance events (1, 2, 5, 10, 25, 50, 100, 250, and 500-yr frequency). Inundation maps for without project condition in Cranford and Robinson's Branch are shown in Figure 17 and Figure 18. Table 4 shows the expected increase in WSEs due to urbanization in the next 50 years for the 4%, 1% and 0.2% annual chance of exceedance events (25, 100 and 500-yr). This results demonstrate a minimal increase in flooding due to expected future urbanization of the basin.

Figure 19 and**Error! Reference source not found.** shows the without project present conditions WSEs profiles for the Rahway River in Cranford and Millburn-Springfield Townships, developed with the first hydraulic model. Figure 21**Error! Reference source not found.** thruFigure 28 show the without project present conditions WSEs profiles for the Rahway River of downstream of Cranford Township, Robinson's and South Branch, developed with the second or improved hydraulic model.

Table 4: Difference in WSEs between future and present without project condition.

Town	**Location**	**W/O Project Future Increase in WSEs (ft.)**		
		4% (25-yr)	1% (100-yr)	0.2% (500-yr)
Springfield/Millburn	Downstream of I-78	0.20	0.15	0.17
Springfield	Just downstream of Morris Ave. Bridge	0.03	0.12	0.03
Springfield	Upstream of Route 22	0.03	0.08	0.03
Cranford	Lenape Park	0.01	0.03	0.01
Cranford	Kenilworth Area	0.04	0.14	0.04
Cranford	Nomahegan Park	0.04	0.10	0.04
Cranford	Below Nomahegan Park - Footbridge	0.04	0.10	0.04
Cranford (Town)	McConnell Park	0.04	0.11	0.04
Cranford (Town)	Hansel Dam Park - Casino Brook Area	0.05	0.10	0.05
Cranford (Town)	From Union Ave. to North Ave. Bridge	0.02	0.07	0.02
Cranford	South Ave. Bridge	0.10	0.13	0.10
Cranford	Just downstream of Lincoln Ave. Bridge	0.13	0.13	0.13

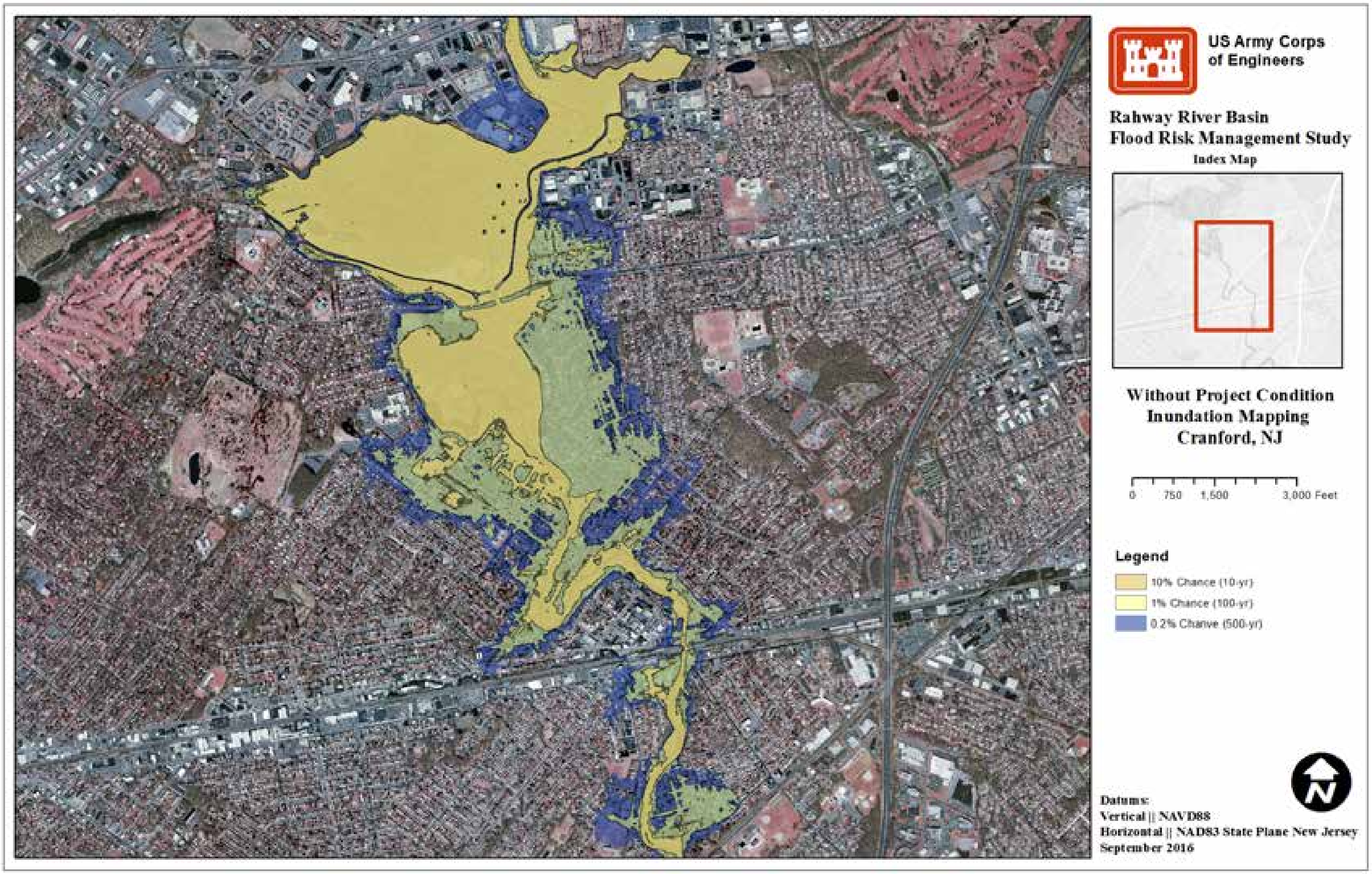

Figure 17: Without project condition inundation map in Cranford Township.

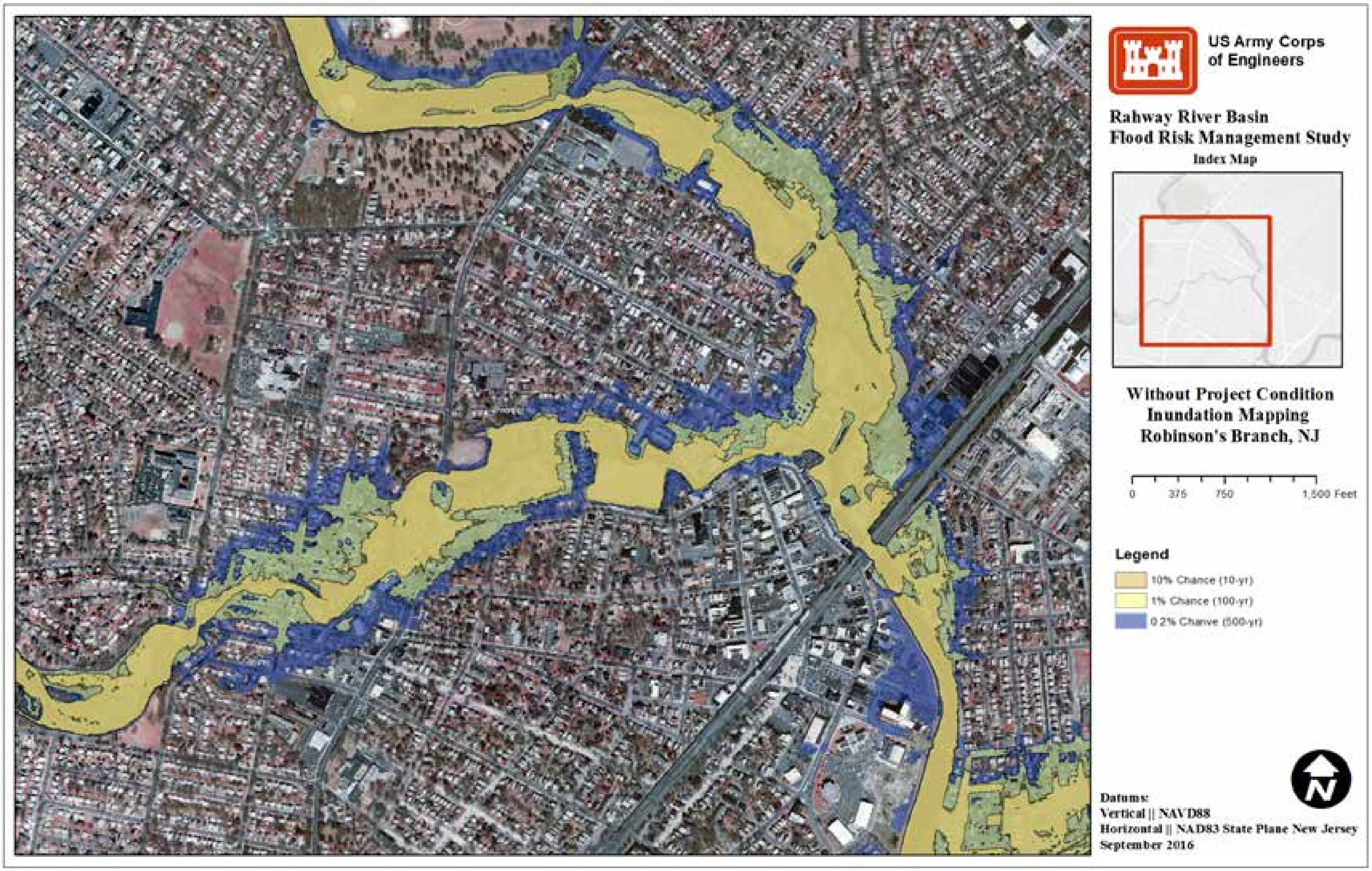

Figure 18: Without project condition inundation map in Robinson's Branch.

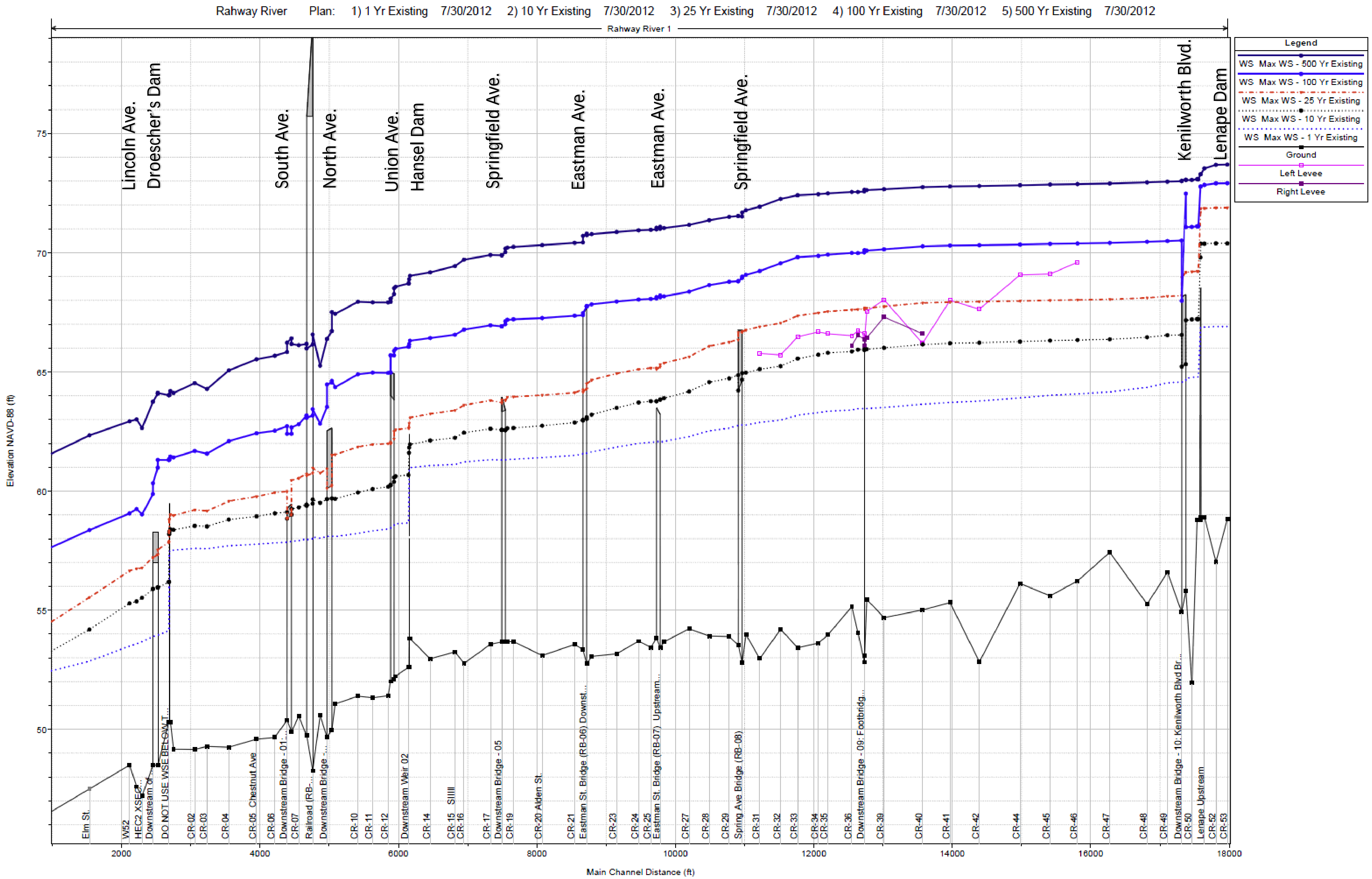

Figure 19: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

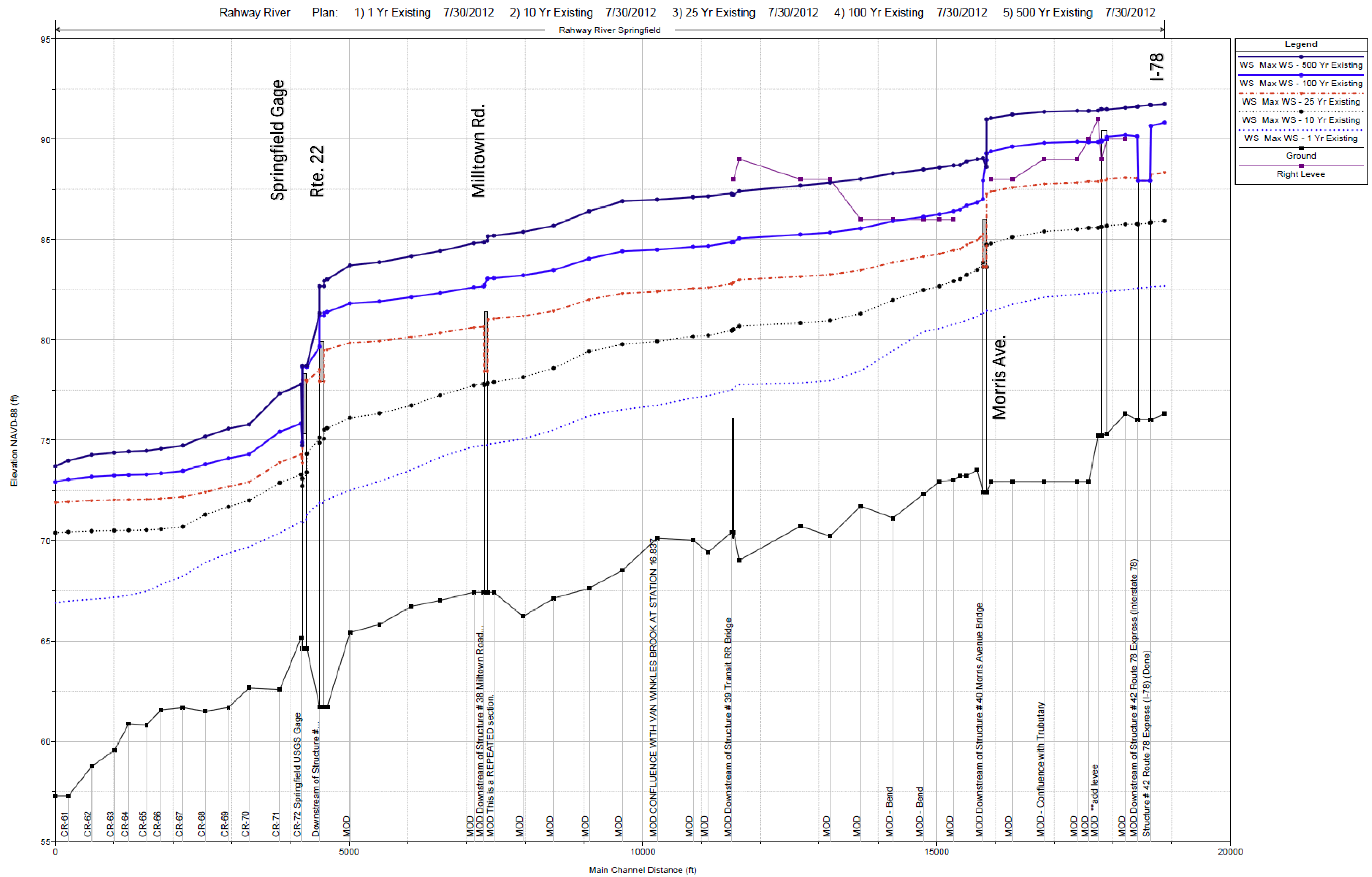

Figure 20: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

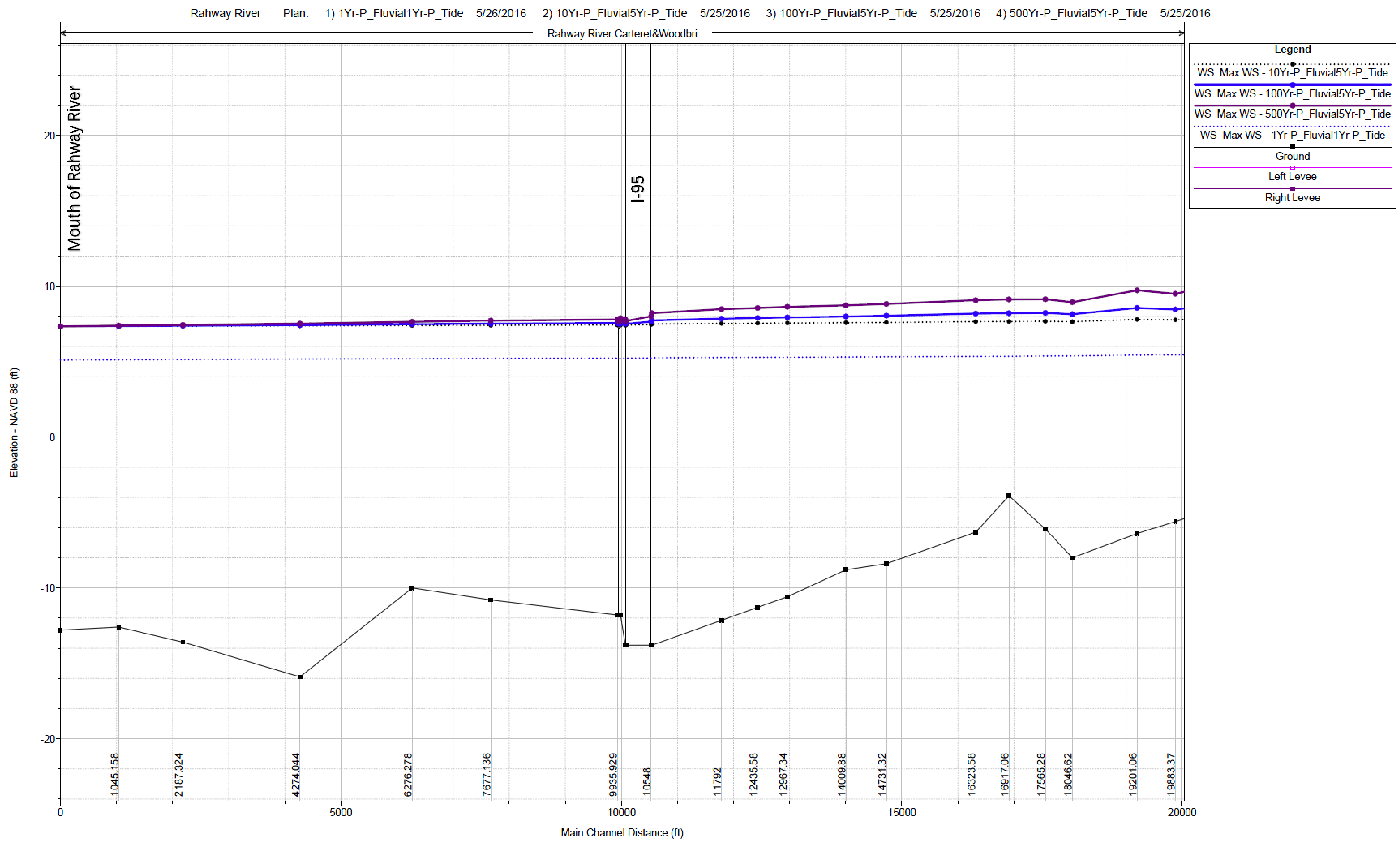

Figure 21: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

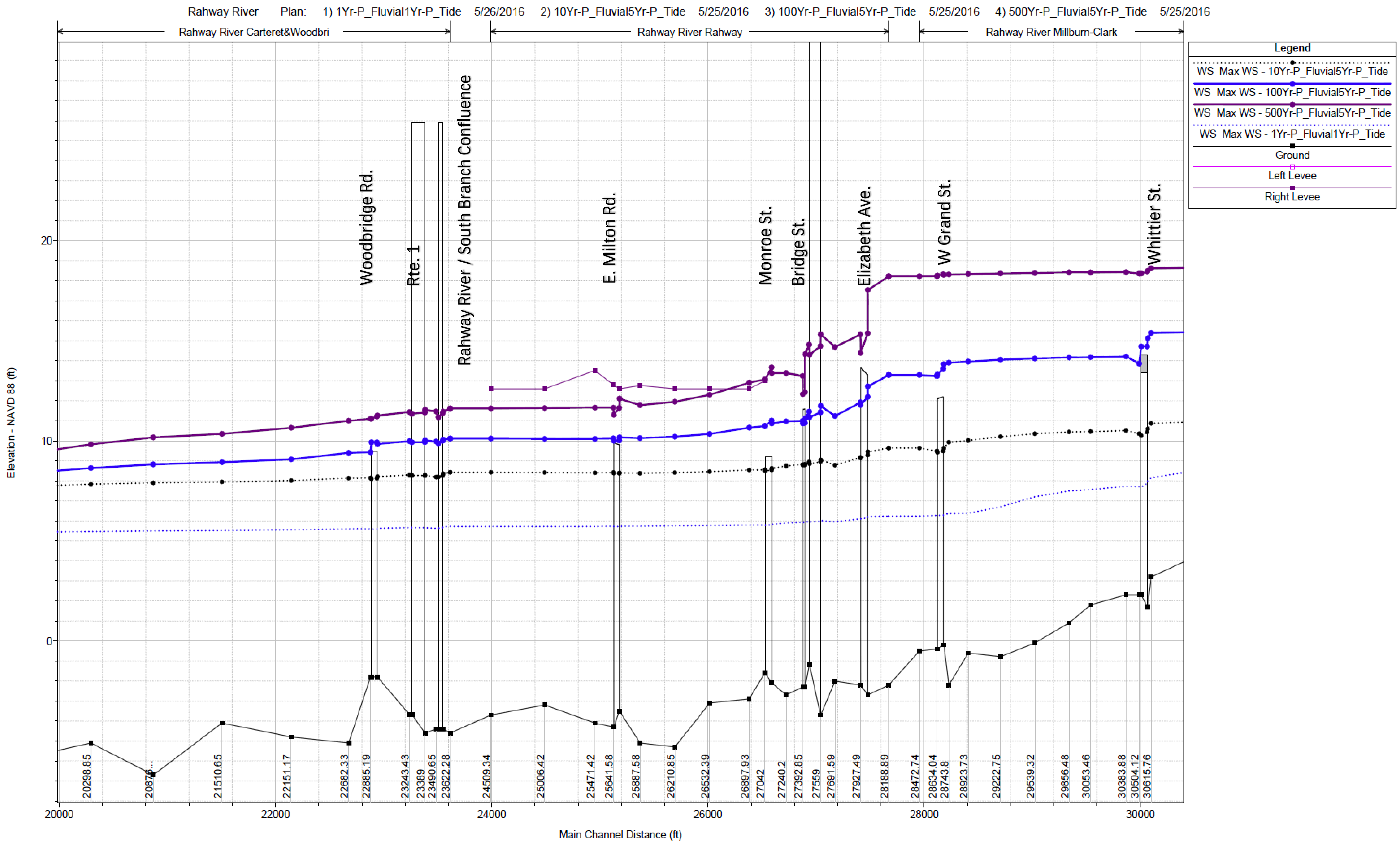

Figure 22: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

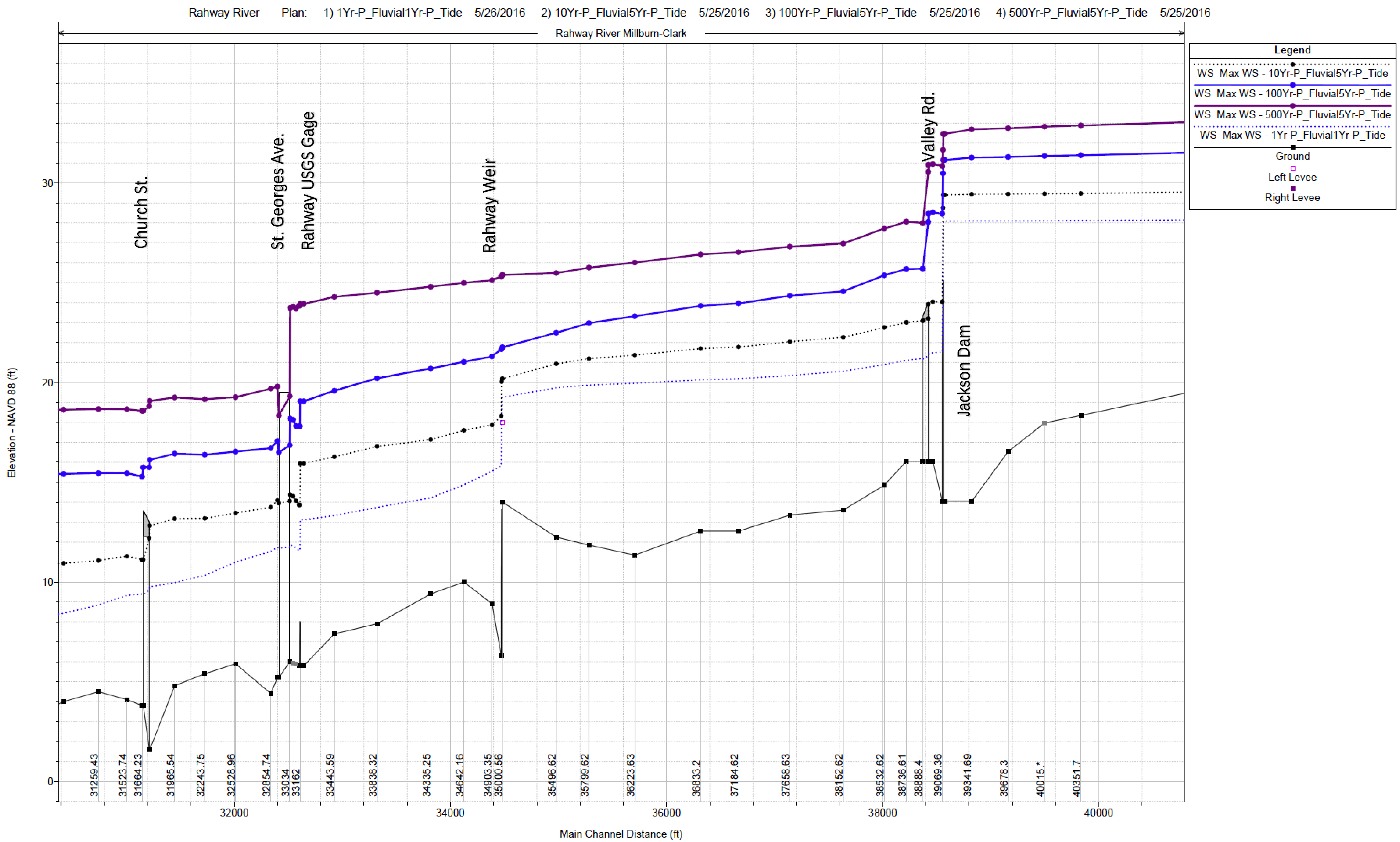

Figure 23: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

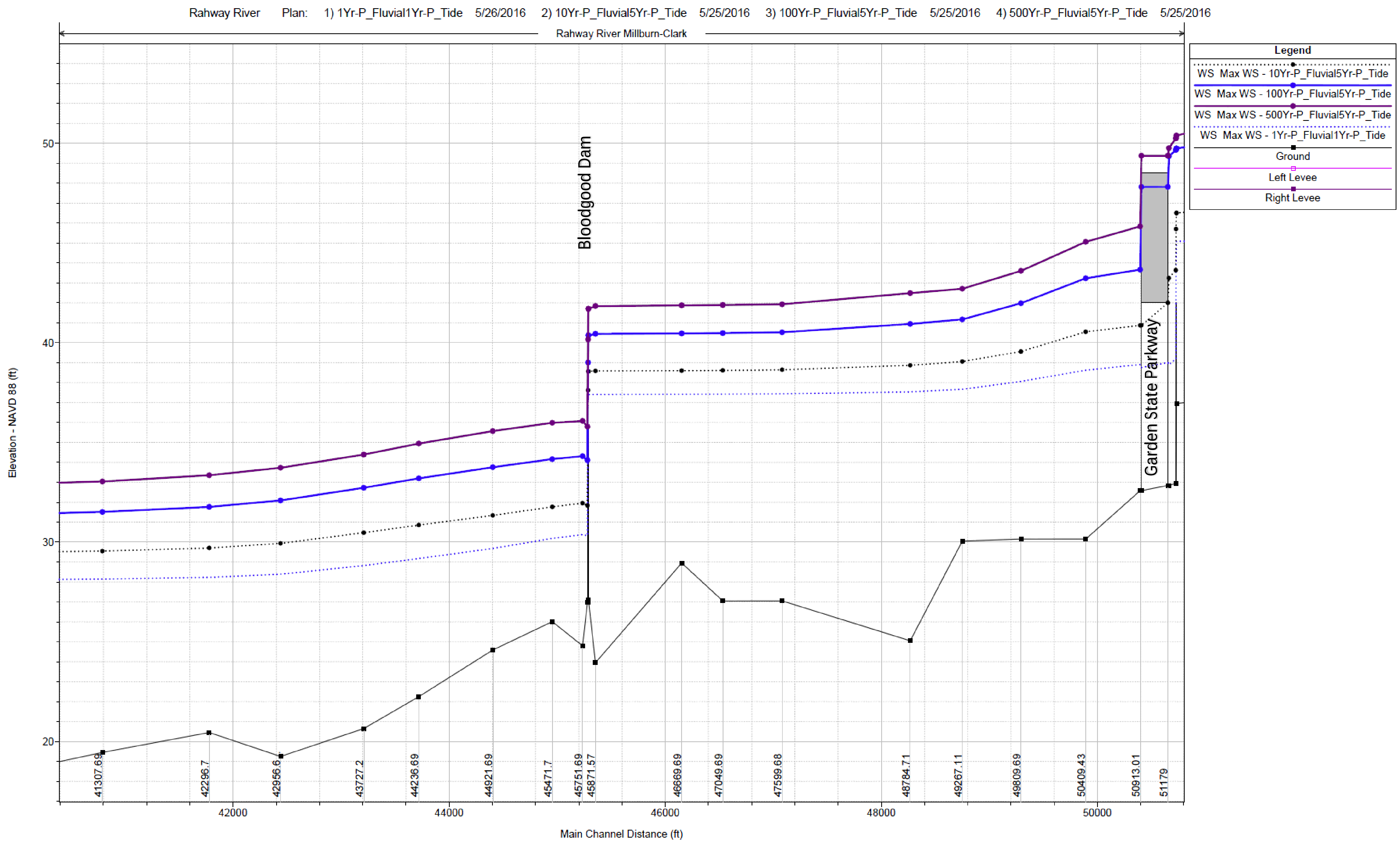

Figure 24: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events.

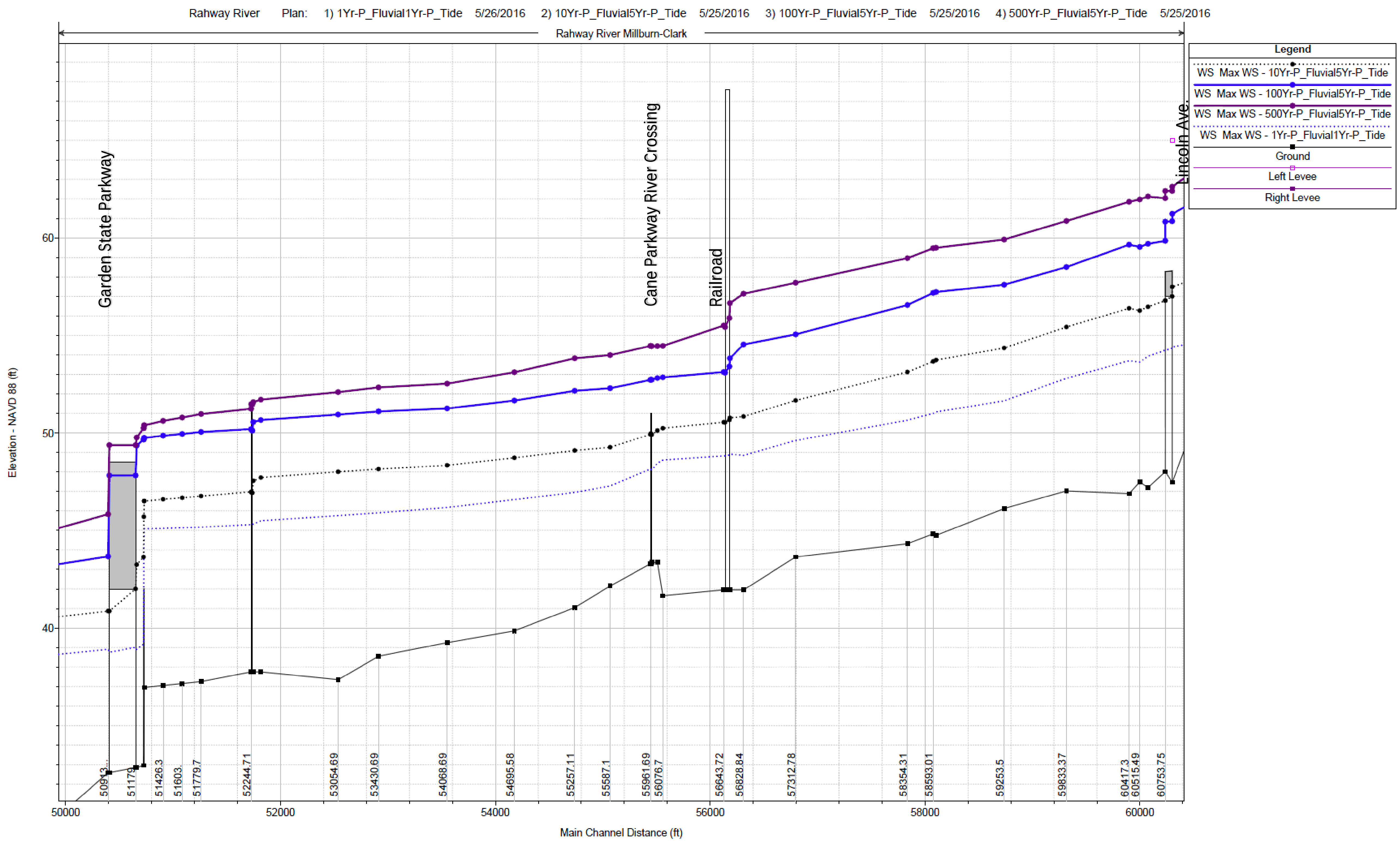

Figure 25: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) event.

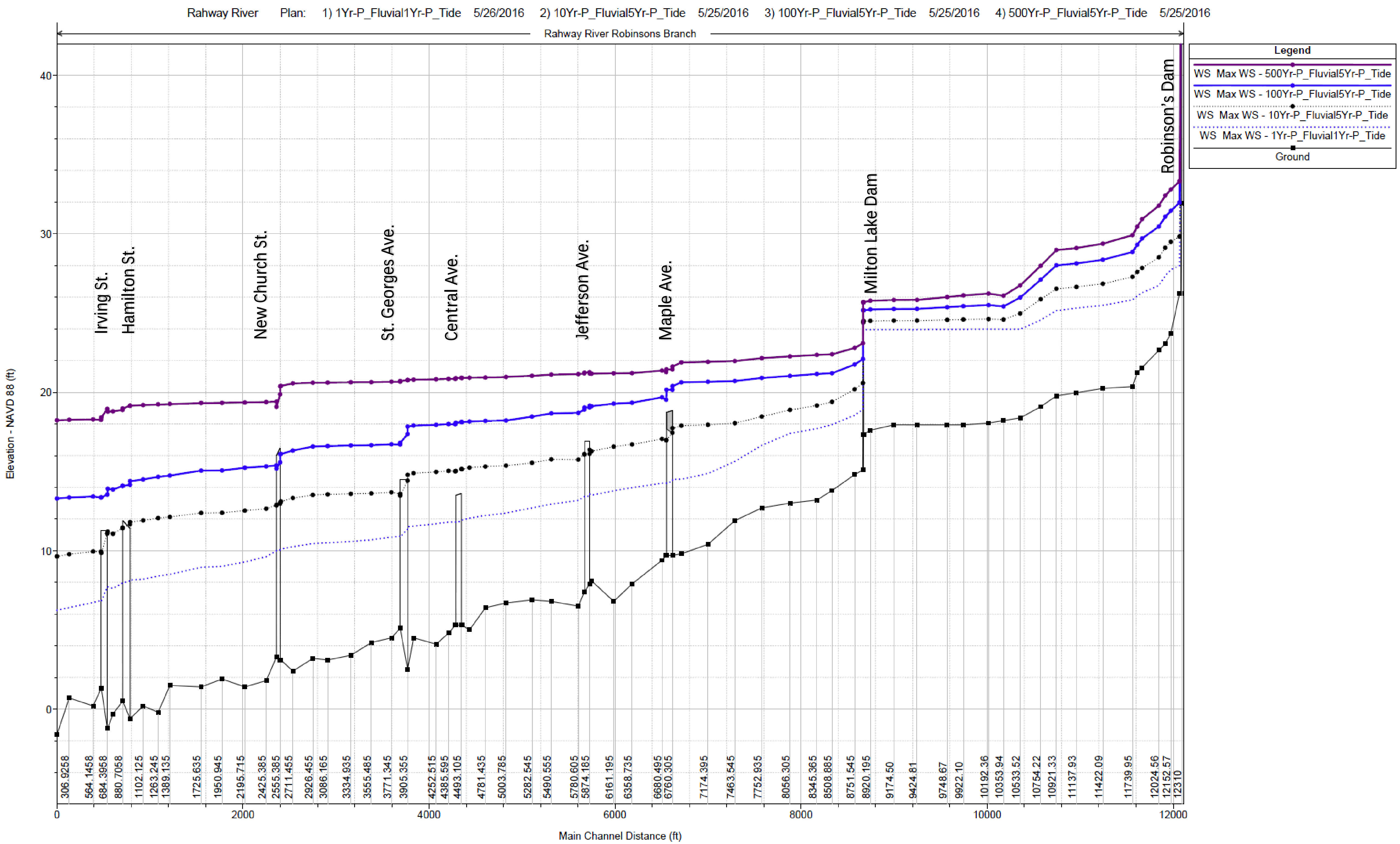

Figure 26: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) event.

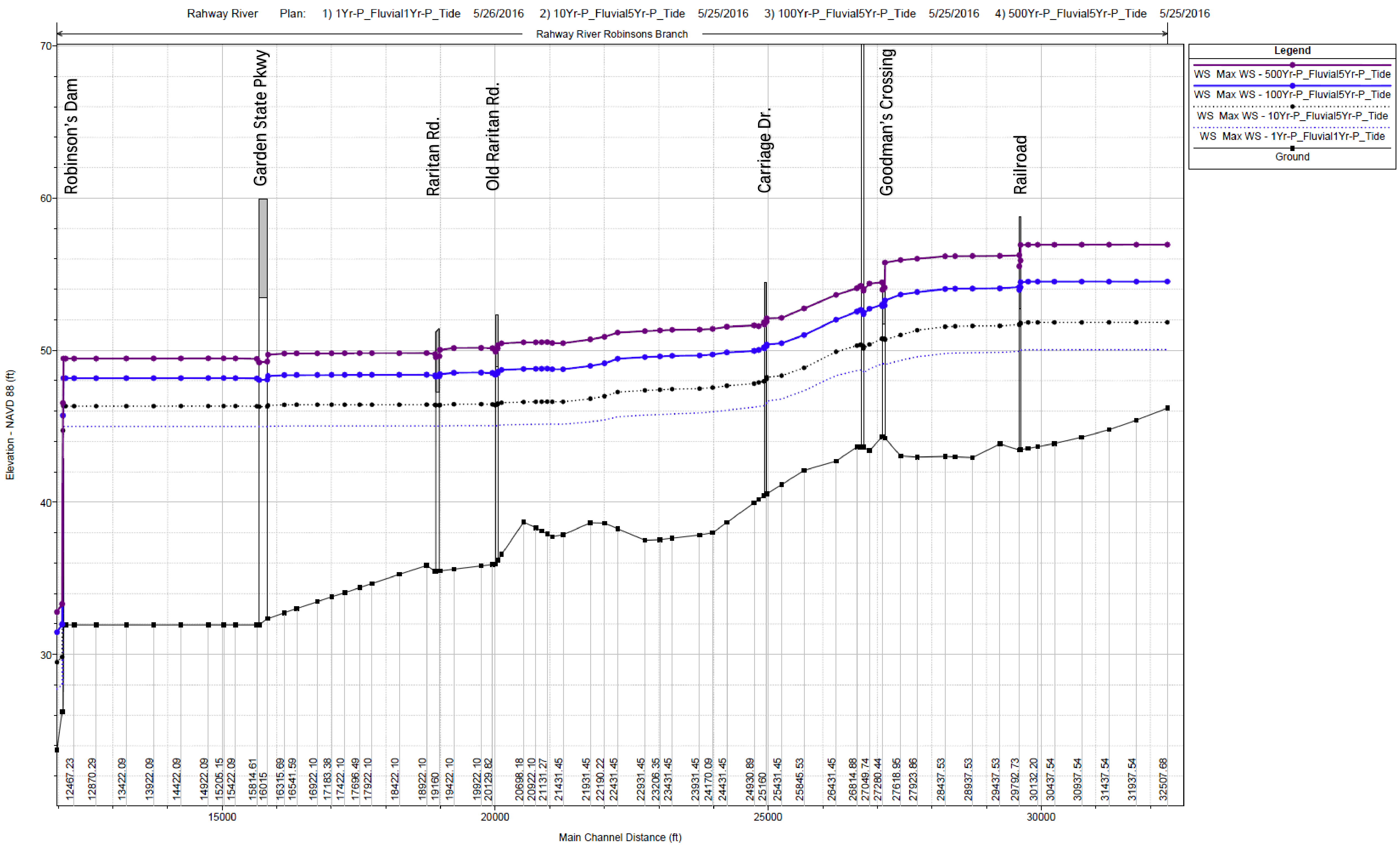

Figure 27: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) event.

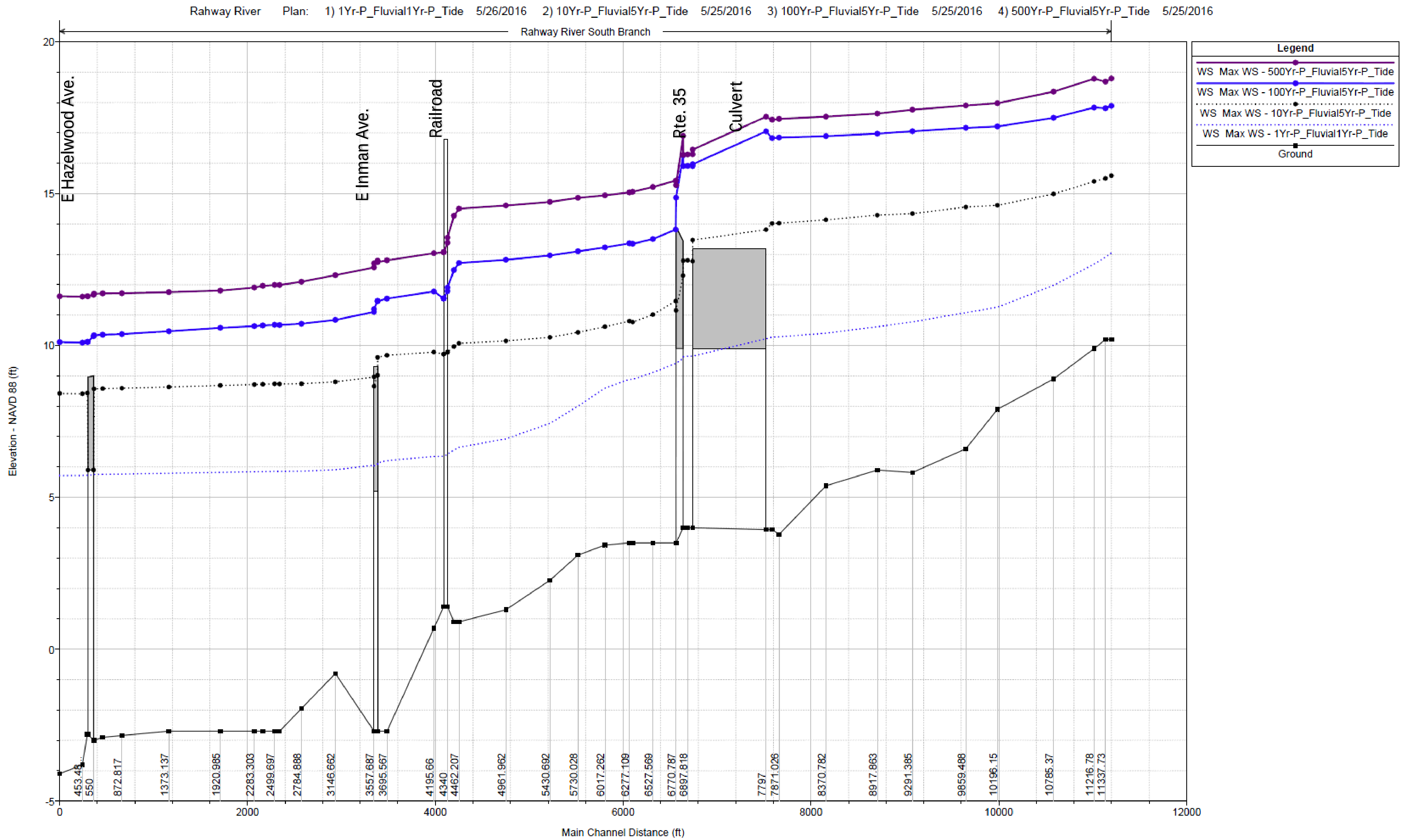

Figure 28: Without project condition computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) event.

4.0 DEVELOPMENT OF ALTERNATIVES

4.1 General

The evaluated alternatives include channel work, levees, floodwalls, reservoirs detention, non-structural, and/or a combination of the above. The alternatives were focused on reducing flood risk in the areas of Cranford Township and City of Rahway on the Robinson's Branch. Other alternatives were preliminary evaluated, but screened out, because of low levels of performance, high cost and potentially high environmental impacts. Modification to Echo Lake Dam, Diversion culvert under Riverside Dr. and modifications to Robinson's Branch Dam (Middlesex Reservoir) are examples of alternatives that were screened out.

4.2 No Action Alternative

This plan involves no federal action to provide flood risk damage reduction in the Rahway River Basin. The no action alternative provides some indication as to what future conditions would be in the absence of the project. The no action alternative would avoid environmental and other impacts associated with implementation of other plans for flood risk damage reduction. The population in the area is stable, the types of industries are stable, the retail structures are expected to turnover without any net change and the climate change trends indicate a small increase in flooding. The local governments are unlikely to fund a large scale flood risk management project. The result would be the continuation and potential exacerbation of flooding problems in the study area.

4.3 Alternatives for Cranford

4.3.1 Alternative #1:

Major channel modification of the Rahway River in Cranford Township, and modification to Lenape Park Detention Basin. This alternative is likely to have a 1% chance of annual exceedance flood (100-yr event) in Cranford Township. The Lenape dam modifications will include:

1. Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
2. Widening the spillway by 100 ft.
3. Widening the low orifice to 40 ft. and lowering by 0.5 ft.
4. Modifying 10,000 ft. dam embankments by raising them 6 ft.
5. Providing a 100 ft. wide vegetation free zone centered around the dam embankments.
6. Widening the auxiliary spillway to 400 ft.
7. Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

This plan also includes approximately 15,500 ft. of channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd., just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The designed slope is approximately 2.6 ft./mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of a natural channel bed or riprap material and a 60 ft. bottom width. The side slopes ranges from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. This alternative is shown in Figure 29 and Figure 30.

Figure 29: Lenape modification footprint.

Figure 30: Channel modification footprint from Lenape Dam to Lincoln Ave. Bridge.

4.3.2 Alternative #2:

Limited channel modification of the Rahway River in Cranford Township, and modification to the Nomahegan levees and Lenape Park Detention Basin. This alternative is likely to have a 1% chance of annual exceedance flood (100-yr event) in Cranford Township. Modification to Lenape Dam are similar to modifications included in alternative #1, see Figure 29 for the Lenape Dam plan view details. The Lenape dam modifications includes:

1. Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
2. Widening the spillway by 100 ft.
3. Widening the low orifice to 40 ft. and lowering by 0.5 ft.
4. Modifying 10,000 ft. dam embankments by raising them 6 ft.
5. Providing 100 ft. wide vegetation free zone centered around the dam embankments.
6. Widening the auxiliary spillway to 400 ft.
7. Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

The levee system to be modified is located in the Nomahegan Park area. The proposed levees and floodwalls are approximately 6 ft. higher than the existing levees. A 15 foot wide vegetation free zone will be added to each side of the reconstructed levees. Because of environmental considerations and the negative impact of a channel through Nomahegan Park, this plan includes reducing channel work to approximately 9,700 ft. throughout the extent of the Rahway River in Cranford Township. The channel work extends from about 200 ft. upstream of Springfield Ave. Bridge to a point approximately 1,000 ft. downstream of the Lincoln Ave. Bridge. The designed slope is approximately 2.7 ft./mile with a maximum deepening of about 4 ft. near Hansel Dam. The trapezoidal channel will consist of a natural channel bed or riprap material and a 70 ft. bottom width. The side slopes ranges from one vertical on two horizontal (1 on 2), to one vertical on two and a half horizontal (1 on 2.5). There will be approximately 3,400 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. See Figure 31 for detailed plan view of the Nomahegan Levees and channel modification and Figure 29 for the Lenape Park Dam modification.

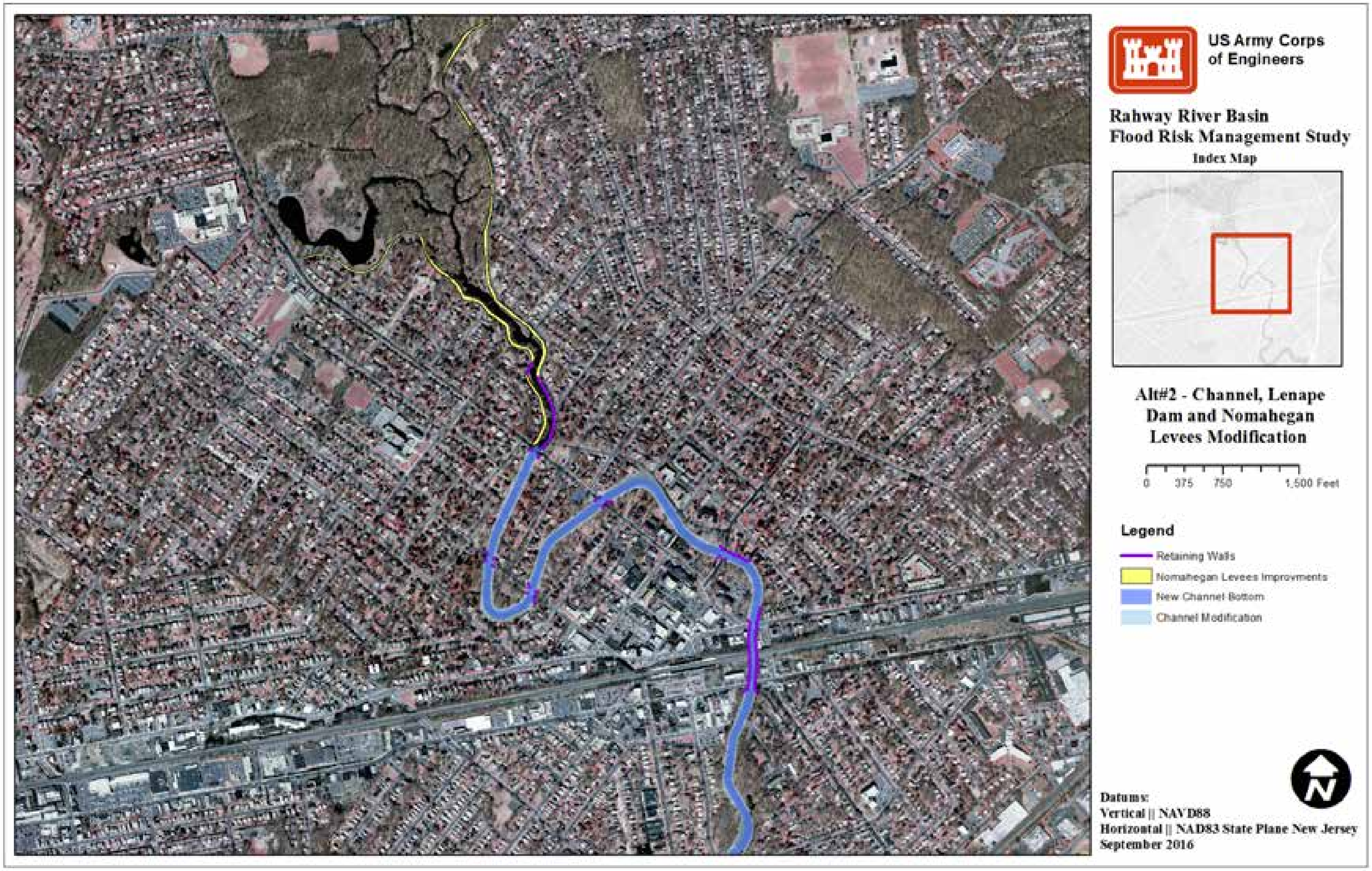

Figure 31: Channel and Nomahegan Levee modification footprint.

4.3.3 *<u>Alternative #3</u>: (this plan was highly cost ineffective therefore no figures have been provided)*

Dredging Orange Reservoir to increase storage capacity and major channel modification of the Rahway River in Cranford Township. This alternative is likely to have between a 2% to a 1% chance of annual exceedance flood (50yr to a100-yr event) in Cranford Township.

This plan includes approximately 15,500 ft. of channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd, just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The designed slope is approximately 2.6 ft./mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of natural channel bed or riprap material and a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative #1, see Figure 30 for the channel modification plan view details.

In addition, this plan includes the use and operation of Orange Reservoir for flood water storage. This included the dredging of approximately 375,000 cyd. of sediment in the reservoir, to return it to its original maximum capacity, and installing additional outlet pipes in the dam structure. The area to be dredge is approximately 65 acres. See Figure 33 for plan view of the reservoir. The additional pipes will help lower the reservoir prior to a storm to maximize the effective use of the new storage capacity of the reservoir.

4.3.4 *Alternative #4:*

Orange Reservoir Dam modifications and channel modification in Cranford Township. This alternative is likely to have between a 2% to a 1% chance of annual exceedance flood (50-yr to a 100-yr event) in Cranford Township.

The plan requires minimum modification to Orange Dam that includes two additional 36 in. diameter outlet pipes at the dam and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum depth of about 30 ft. to a depth of about 15 feet. This plan requires little to no dredging in the reservoir. See Figure 33 for plan view and footprint of the dam.

This plan also includes approximately 15,500 ft. channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd, just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of the channel work is expected in Nomahegan Park. The designed slope is approximately 2.6 ft./mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The new trapezoidal channel will consist of a combination of natural channel bed or riprap material and a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of replaced retaining walls. Also, the N. Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative #1, see Figure 30 for the channel modification plan view details. Channel modification in this alternative is similar to modifications included in alternative #1, see Figure 30 for the channel modification plan view details.

4.3.5 Alternative #4A - Tentatively Selected Plan (TSP):

Replacement in-kind of Orange Dam (see Figure 33) with outlet modifications and limited channel modification in Cranford Township. This alternative is likely to have a 2% to 4% chance of annual exceedance flood (25-yr event ~ 50-yr event) in Cranford Township. The plan requires two additional 36 in. diameter outlet pipes at the dam and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum reservoir depth of about 30 ft. to a depth of about 15 feet. A recent bathymetric survey determined that the reservoir has 200 ac-ft. more storage capacity at the spillway elevation (see Figure 32) than was assumed earlier in this study. Thus, the recommended final drawdown elevation will be adjusted based on acceptable reservoir re-fill times, environmental consideration and the desired level of protection. This plan requires little to no dredging in the reservoir.

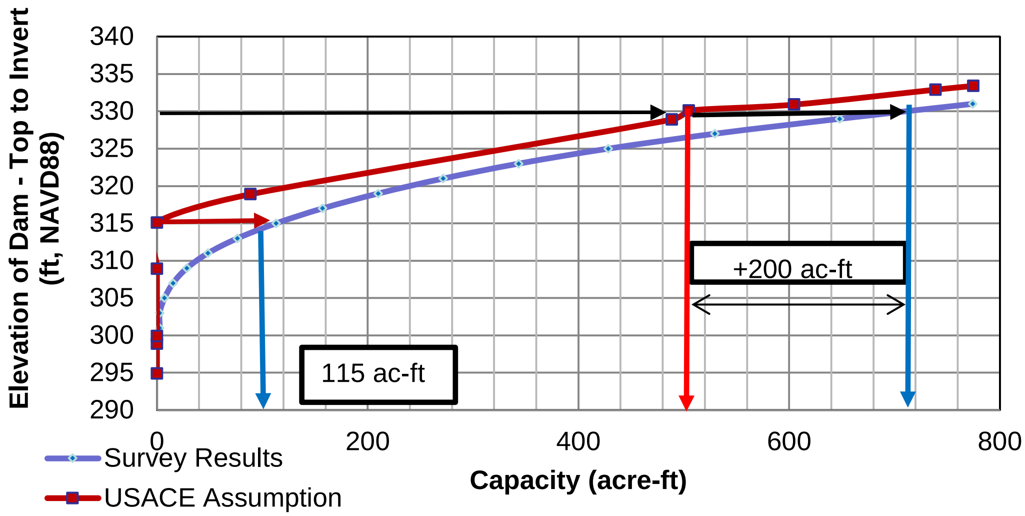

Figure 32: Capacity determined by bathymetry survey of Orange Reservoir during the summer of 2015.

This plan also requires approximately 8,930 ft. of channel modification. The proposed channel modification starts in the vicinity of the footbridge by Nomahegan Park and ends approximately 650 ft. downstream of South Ave. E. The designed slope is approximately 2.6 ft./mile with a maximum deepening of about 1.9 ft. in the vicinity Hansel Dam. The new trapezoidal channel will consist of a natural channel bed with a 35 to 45 ft. bottom width and side slopes of one vertical on two and a half horizontal (1:2.5). There is some riprap material in a small segment of the river near the Eastman Ave. Bridge at McConnell Park. No dam or bridge removals in the vicinity of Cranford were included in this alternative. See Figure 34 for plan view details of the modified channel.

Figure 33: Orange Reservoir and dam footprint.

Figure 34: Reduced channel modification along the Rahway River in Cranford.

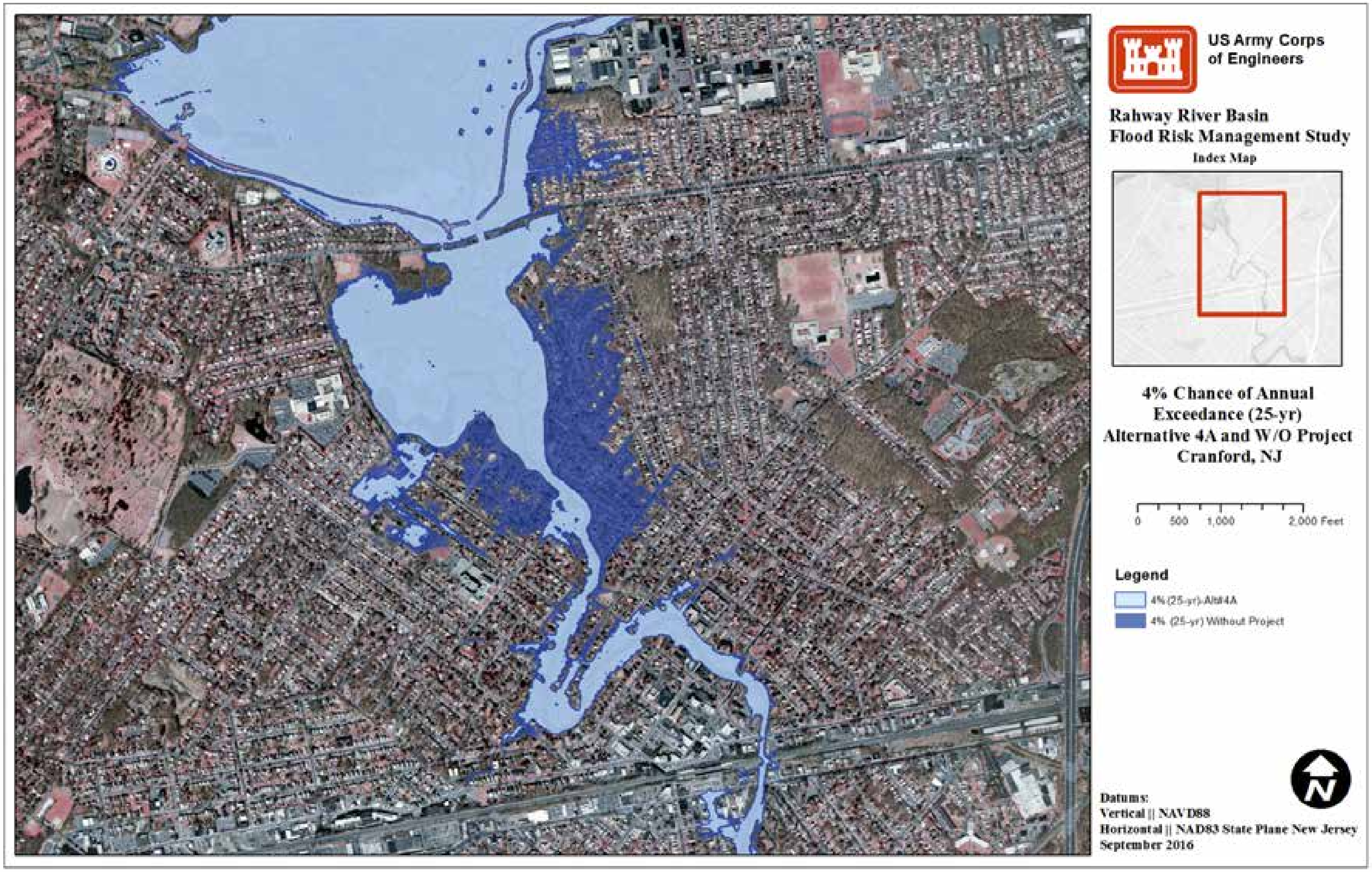

Figure 35: Alternative #4A 4% chance of annual exceedance (25-yr) inundation map

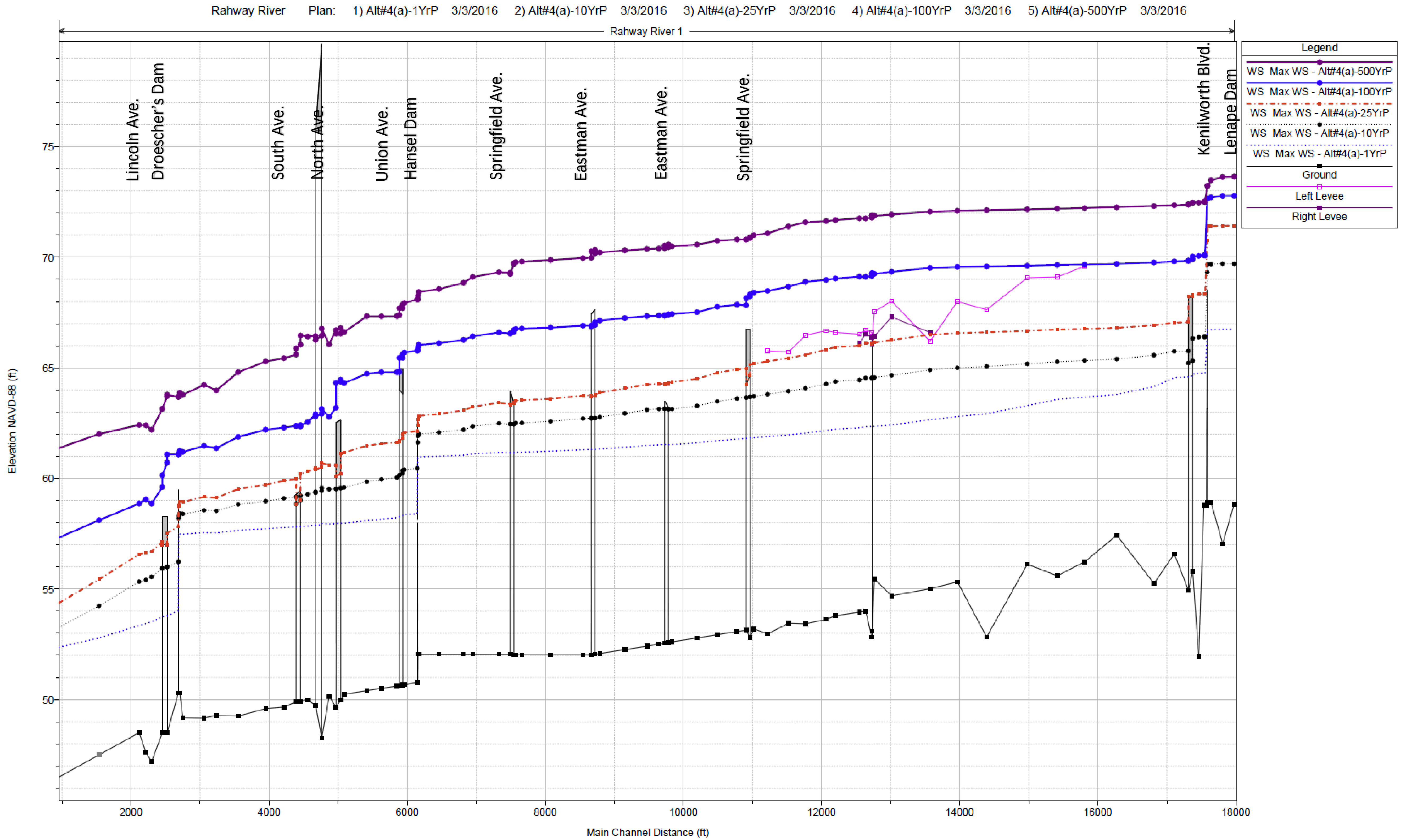

Figure 36: Alternative #4A computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events in Cranford, NJ.

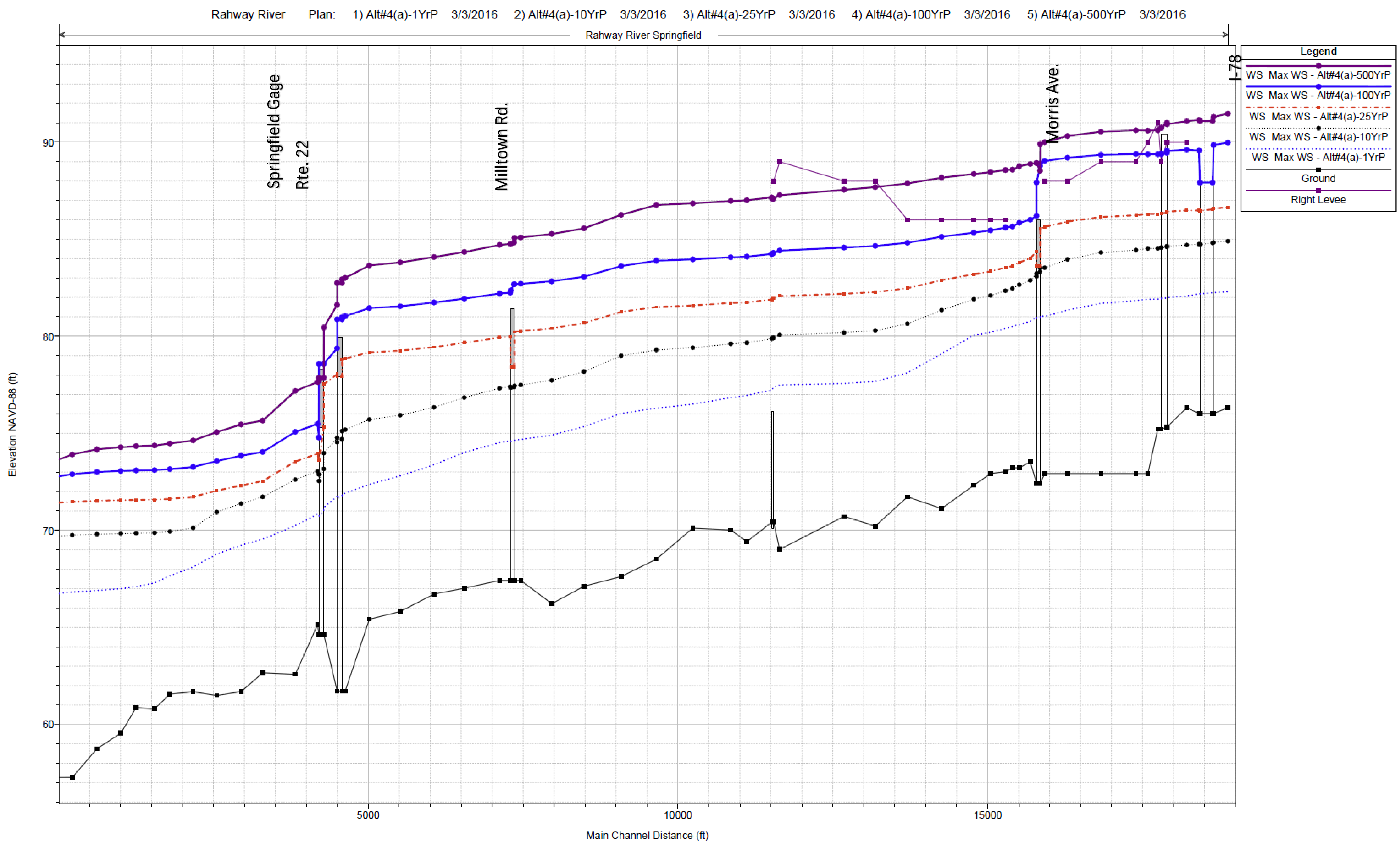

Figure 37: Alternative #4A computed water surface profile for the 99.9, 4, 1 and 0.2% chance of annual exceedance (1-yr, 25-yr, 100-yr and 500-yr) events in Springfield, NJ.

4.3.6 Alternative #5:

The plan consist of channel modification at the Rahway River at Cranford Township and the construction of a South Mountain Dry Detention Basin with Brookside Drive relocated to provide uninterrupted traffic access. The alternative is likely to have a 1% chance of annual exceedance (100-yr event) in Cranford Township.

This plan includes approximately 15,500 ft. channel work throughout the extent of the Rahway River in Cranford Township, from Kenilworth Blvd., just downstream of Lenape Dam, to a point approximately 1,500 ft. downstream of the Lincoln Avenue Bridge. Approximately 1,400 ft. of channel work is expected in Nomahegan Park. The designed slope is approximately 2.6 ft./mile with a maximum deepening of about 3.7 ft. near Hansel Dam. The trapezoidal channel will consist of a combination of natural bed channel or riprap material, a 60 ft. bottom width with side slopes ranging from one vertical on two horizontal (1:2), to one vertical on two and a half horizontal (1:2.5). There will be approximately 2,000 ft. of new and removed/replaced retaining walls. Also, the Union Ave. and North Ave. Bridges will be removed and replaced. Channel modification in this alternative is similar to modifications included in alternative #1, see Figure 30 for the channel modification plan view details.

In addition, this plan includes a new dry detention structure in South Mountain Reservation just upstream of Campbell’s Pond. The structure will be approximately 810 ft. long by 75 ft. high. The area flooded during a storm event of 0.2% chance of exceedance (500-yr event) is approximately 85 acres and the dam structure will have a footprint of approximately 6.6 acres. The dry detention structure will provide approximately 2,500 acre-ft. of flood water storage to the downstream communities.

This plan also requires the relocation of approximately 3,000 ft. Brookside Drive and a steel truss maintenance bridge across the spillway of the dam. The relocated road relocated along the left bank of dam, allowing traffic flow during flood events and access to the top of the dam for maintenance and emergency operation. Currently this road gets flooded during the less frequent events. See Figure 38 for a plan view of South Mountain dry detention dam.

Figure 38: Proposed South Mountain dry detention dam and Brookside Drive relocation.

4.3.7 *Alternative #6:*

The plan consist of a new dry detention structure in South Mountain Reservation (standalone) with Brookside Drive relocated to provide uninterrupted traffic access. The structure will be approximately 810 ft. long by 75 ft. high. The area flooded during a storm event of 0.2% chance of exceedance (500-yr event) is approximately 85 acres and the dam structure will have a footprint of approximately 6.6 acres. The dry detention structure will provide approximately 2,500 acre-ft. of flood water storage to the downstream communities.

This plan also requires the relocation of approximately 3,000 ft. Brookside Drive and a steel truss maintenance bridge across the spillway of the dam. The relocated road relocated along the left bank of dam, allowing traffic flow during flood events and access to the top of the dam for maintenance and emergency operation. Currently this road gets flooded during the less frequent events. See Figure 38 for a plan view of South Mountain dry detention dam.

4.3.8 *Alternative #7A and 7B:*

Nonstructural Plans with a 10% and 1% chance of annual exceedance (10-yr and 100-yr) along the Rahway River in Cranford. The non-structural flood proofing measures considered in this project were:

- *Dry Flood Proofing*. Dry flood proofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure. Dry flood proofing measures considered in this screening make the portion of a building that is below the flood level watertight through attaching watertight closures to the structure in doorway and window openings.
- *Wet Flood Proofing*. Wet flood proofing measures allow flood water to get inside lower, non-living space areas of the structure via vents and openings in order to reduce the effects of hydrostatic pressure and, in turn, reduce flood-related damages to the structure’s foundation.
- *Elevation (aka. Raise)*. Elevation involves raising the lowest finished floor of a building to a height that is above the flood level. In some cases, the structure is lifted in place and foundation walls are extended up to the new level of the lowest floor.
- *Buyouts*. It involves the purchase and elimination of flood damaged structures, allowing owners to move to places away from flood risk.

One structural measure that was included in these plans was:

- *Barriers (aka. Ringwall)*. Barriers usually surround the building but are not attached, such as in the case of ringwalls, levees, or berms. It is used where the elevation isn't feasible.

Nonstructural measures are being finalized for approximating 700 structures contained in the 1% annual exceedance (100-yr event) and approximating 100 structures contained in the 10% annual exceedance (10-yr event) flood inundation areas for the Rahway River in Cranford. All structures will be treated to an elevation of one foot above the 1% annual exceedance event. Completed non-structural plans for the 10% and 1% annual exceedance events are summarized in Table 5 and shown in Figure 39.

Table 5: Number of structures to be treated in Rahway River at Cranford Non-structural Plan for the 10% and 1% annual exceedance events.

Nonstructural Flood Proofing Measure	**10% (10-yr) Annual Exceedance**			**1% (100-yr) Annual Exceedance**		
	Residential	**Non-Residential**	**Sub Total**	**Residential**	**Non-Residential**	**Sub Total**
Dry Flood proofing	0	0	0	7	4	11
Wet Flood proofing	1	0	1	326	0	326
Barriers	1	0	1	32	5	37
Raise	62	0	62	310	1	311
Buyout	2	0	2	36	5	41
Total of Structures	66	0	**66**	711	15	**726**

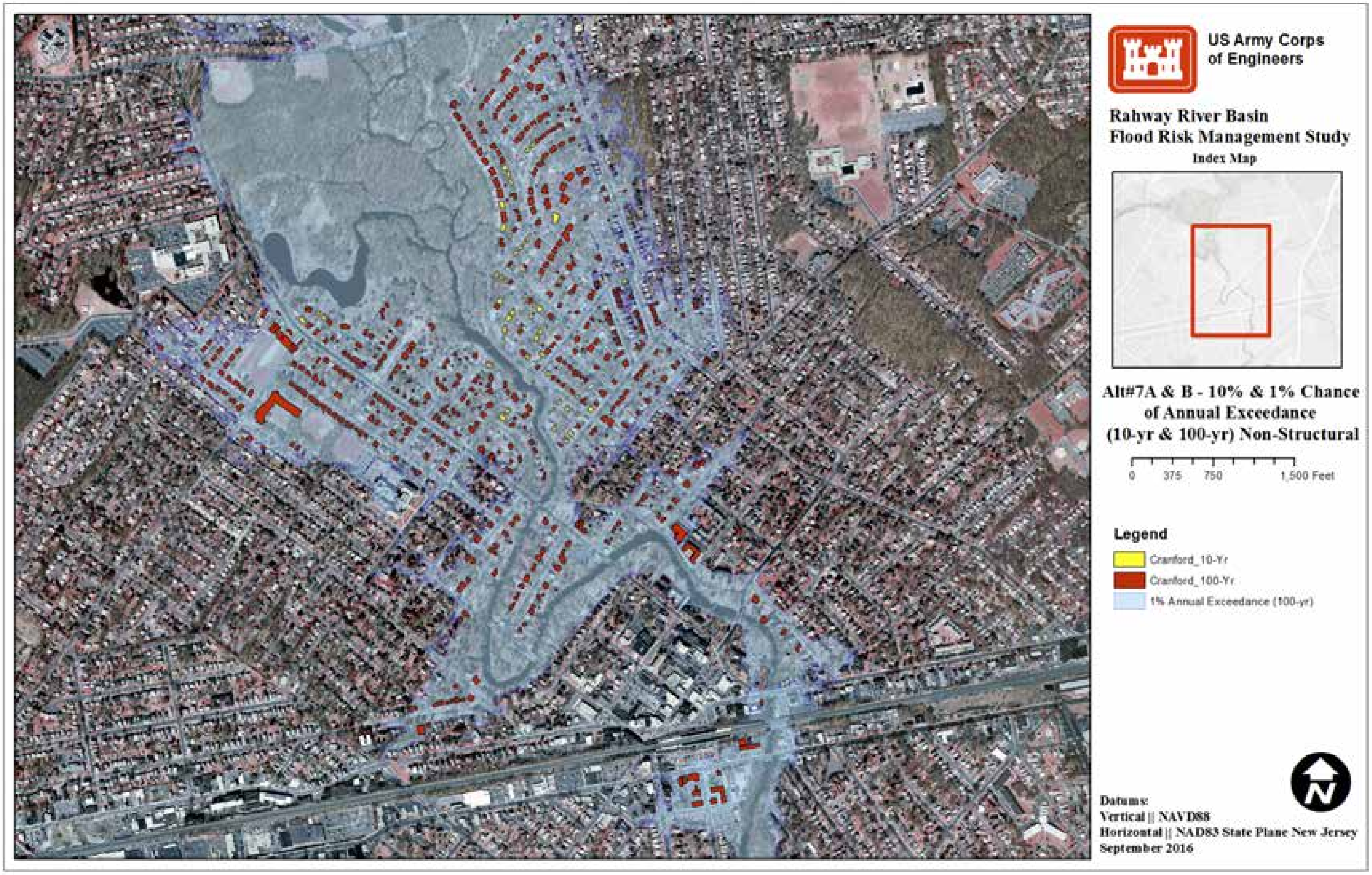

Figure 39: 10% and 1% chance of annual exceedance non-structural alternative in Cranford Township.

4.3.9 Alternative #8:

The alternative consist on the replacement of Lenape and Orange Dams. The Lenape dam replacement will include:

1. Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
2. Widening the spillway by 100 ft.
3. Widening the low orifice to 40 ft. and lowering by 0.5 ft.
4. Removing approximately 10,000 ft. existing earthen dam embankments and replacing with a 6 ft. higher embankment. Also widening the top of the embankments to 25 ft.
5. Providing a 100 ft. wide vegetation free zone centered around the dam embankments.
6. Widening the auxiliary spillway to 400 ft.
7. Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

The plan requires the replacement in-kind of Orange Dam and includes two additional 36 in. diameter outlet pipes and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum reservoir depth of about 30 ft. to a depth of about 15 ft. This plan requires little to no dredging in the reservoir. The plan views of the alternative is shown in Figure 29 and 33.

4.3.10 Alternative #9:

The alternative consist on the replacement of Lenape and Orange Dams, and limited channel modification in Cranford. The Lenape dam replacement includes:

1. Replacing the existing Lenape Dam spillway structure and raising by 6 ft.
2. Widening the spillway by 100 ft.
3. Widening the low orifice to 40 ft. and lowering by 0.5 ft.
4. Removing approximately 10,000 ft. existing earthen dam embankments and replacing with a 6 ft. higher embankment. Also widening the top of the embankments to 25 ft.
5. Providing a 100 ft. wide vegetation free zone centered around the dam embankments.
6. Widening the auxiliary spillway to 400 ft.
7. Adding 6 ft. of floodwalls to the existing embankments in the northern area of Lenape Park near Fadem Rd. at Springfield Township.

There will be approximately 8,930 ft. channel work throughout the extent of the Rahway River in Cranford Township, from the footbridge at Nomahegan Park to a point approximately 650ft. downstream of the South Ave. Bridge. The general designed slope of the channel cut will be approximately 2.6 ft./mile with a maximum deepening of about 1.9 ft. in the vicinity of Hansel Dam. The new trapezoidal channel will consist of a natural bed channel with a 35 to 45 ft. bottom width and side slopes of one vertical on two and a half horizontal (1:2.5). There is some riprap material in a small segment of the river near the Eastman Ave. Bridge at McConnell Park. No dam or bridge removal in Cranford is expected in this alternative. The plan view of the proposed channel in this alternative is shown in Figure 34.

The plan requires the replacement in-kind of Orange Dam and includes two additional 36 in. diameter outlet pipes and operation two days prior to a storm event. The required drawdown is approximately 15 ft., from a maximum depth of about 30 ft. to a depth of about 15 ft. This plan requires little to no dredging in the reservoir. The plan views of the remaining features of this alternative is shown in Figure 29.

4.4 Cranford Alternatives Results

The improved hydraulic condition analysis shows that the alternatives with the greatest flood risk reduction are alternatives #1 and #5. Both of these alternatives have major channel modification along the Rahway River at Cranford and an upstream detention feature that mitigates for the downstream induced damages. Detention features, as the proposed South Mountain Dry Detention Basin and the modifications to Orange Reservoir, would produce additional benefits to Millburn and Springfield. Reduction in WSEs raging between 4 and 5 ft. are expected with these alternatives in the Township of Cranford, as seen in Table 6 thruTable 8. The economic analysis concluded that alternative #4A is the most cost effective alternative, but the reduction in WSEs in Cranford is small compared to other alternatives. This alternative still produces benefits to Millburn and Springfield Townships. Optimization of the alternative #4A channel depth, width and length, as well the operation of Orange Reservoir Dam is the next step of the hydraulic analysis.

Table 6: Decrease in flood elevation from without project condition for the 4% chance of annual exceedance (25-yr) flood.

Town	Location	*Reduction in the 25yr WSE ft. (Existing -Alternatives)							
		Alt #1	**Alt #2**	**Alt#4**	**Alt#4A**	**Alt#5**	**Alt#6**	**Alt#8**	**Alt#9**
Springfield/Millburn	Downstream of I-78	0.0	0.0	1.6	1.6	3.0	3.1	1.6	1.6
Springfield	Just downstream of Morris Ave. Bridge	0.0	0.0	1.0	1.0	1.8	1.8	1.0	1.0
Springfield	Upstream of Route 22	0.0	0.0	0.7	0.7	1.6	1.5	0.7	0.7
Cranford	Lenape Park	-1.4	-1.8	0.9	0.5	1.4	0.8	-0.7	-0.7
Cranford	Kenilworth Area	5.7	2.3	4.6	0.9	5.2	1.2	1.5	2.2
Cranford	Nomahegan Park	5.4	2.4	4.2	1.3	4.9	1.1	1.2	2.2
Cranford	Below Nomahegan Park - Footbridge	5.9	3.0	4.6	1.5	5.3	1.1	1.3	2.5
Cranford (Town)	McConnell Park	4.8	5.9	3.6	0.9	4.2	0.9	1.1	1.6
Cranford (Town)	Hansel Dam Park - Casino Brook Area	4.2	5.4	3.0	0.4	3.7	0.7	1.0	0.9
Cranford (Town)	From Union Ave. to North Ave. Bridge	3.5	4.6	2.2	0.4	3.1	0.9	1.5	1.1
Cranford	Downstream South Ave. Bridge	2.8	3.8	1.5	0.1	2.6	0.5	0.6	0.5
Cranford	Just downstream of Lincoln Ave. Bridge	1.0	3.0	0.1	0.1	2.3	0.8	1.0	0.8

*Negative numbers denote an increase in flood elevation.

Table 7: Decrease in flood elevation from without project condition for the 1.0% chance of annual exceedance (100-yr) flood.

Town	Location	*Reduction in the 100yr WSE ft. (Existing -Alternatives)							
		Alt #1	**Alt #2**	**Alt#4**	**Alt#4A**	**Alt#5**	**Alt#6**	**Alt#8**	**Alt#9**
Springfield/Millburn	Downstream of I-78	0.0	0.0	0.5	0.5	2.7	2.7	0.5	0.5
Springfield	Just downstream of Morris Ave. Bridge	0.0	0.0	0.9	0.9	2.0	1.9	0.9	0.9
Springfield	Upstream of Route 22	0.0	0.0	0.3	0.4	0.8	0.8	0.3	0.4
Cranford	Lenape Park	-4.0	-4.0	0.4	0.1	0.9	0.4	-3.7	-3.9
Cranford	Kenilworth Area	3.3	1.3	2.0	1.0	3.1	1.2	1.3	1.4
Cranford	Nomahegan Park	4.2	1.6	3.1	0.7	4.1	0.9	1.1	1.9
Cranford	Below Nomahegan Park - Footbridge	4.5	2.0	3.3	0.8	4.3	0.9	1.1	2.0
Cranford (Town)	McConnell Park	4.1	4.9	3.1	0.7	3.9	1.0	1.3	1.8
Cranford (Town)	Hansel Dam Park - Casino Brook Area	3.8	4.6	2.8	0.3	3.5	0.9	1.2	1.3
Cranford (Town)	From Union Ave. to North Ave. Bridge	2.8	3.7	1.7	0.2	2.6	0.8	1.3	1.4
Cranford	Downstream South Ave. Bridge	2.2	3.0	1.4	0.2	2.2	1.3	1.8	1.8
Cranford	Just downstream of Lincoln Ave. Bridge	1.0	2.8	0.2	0.2	2.2	1.0	1.3	1.4

*Negative numbers denote an increase in flood elevation.

Table 8: Decrease in flood elevation from without project condition for the 0.2% chance of annual exceedance (500-yr) flood.

Town	Location	*Reduction in the 500yr WSE ft. (Existing -Alternatives)							
		Alt #1	**Alt #2**	**Alt#4**	**Alt#4A**	**Alt#5**	**Alt#6**	**Alt#8**	**Alt#9**
Springfield/Millburn	Downstream of I-78	0.0	1.5	0.8	0.8	1.7	1.7	0.8	0.7
Springfield	Just downstream of Morris Ave. Bridge	0.0	2.2	0.1	0.1	2.3	2.3	0.1	0.1
Springfield	Upstream of Route 22	0.0	2.0	0.1	0.1	1.2	1.2	0.1	0.1
Cranford	Lenape Park	-4.0	-4.0	0.1	0.1	0.5	0.4	-3.8	-4.0
Cranford	Kenilworth Area	1.1	1.0	1.0	0.6	2.9	1.2	0.6	0.9

Cranford	Nomahegan Park	2.3	1.2	2.0	0.7	3.1	1.2	0.6	1.0
Cranford	Below Nomahegan Park - Footbridge	2.3	1.4	2.1	0.8	3.2	1.3	0.6	1.1
Cranford (Town)	McConnell Park	2.2	2.7	1.9	0.6	3.1	1.3	0.5	0.7
Cranford (Town)	Hansel Dam Park - Casino Brook Area	1.8	2.5	1.6	0.6	2.7	1.4	0.4	0.4
Cranford (Town)	From Union Ave. to North Ave. Bridge	1.3	2.1	1.3	0.6	2.6	2.2	0.1	0.1
Cranford	Downstream South Ave. Bridge	1.4	1.9	1.0	0.2	2.8	1.4	0.9	1.0
Cranford	Just downstream of Lincoln Ave. Bridge	0.8	2.3	0.2	0.5	3.3	1.9	1.2	1.4

*Negative numbers denote an increase in flood elevation.

4.5 Alternatives for Robinson's branch

4.5.1 Alternative #1:

This alternative is a reevaluation of the 1985 GRR Plan which consists of levees, floodwalls and channel modification. This plan includes approximately 8,300 ft. of channel work throughout the Robinson's Branch and Rahway River. In Robinson's Branch, the channel starts about 600 ft. downstream of Maple Ave. Bridge and ends in the confluence with Rahway River. In the Rahway River, the channel starts about 75 ft. upstream of W Grand Ave. Bridge and ends approximately 550 ft. downstream of the Monroe Ave. Bridge. All channel cuts generally consist of a 35 ft. wide trapezoidal channel with natural bed and one vertical on two and a half horizontal (1:2.5) side slopes. There are also a few sections with rectangular cuts of 60 ft. width and 20 ft. wide pilot channels, in Robinson's Branch. Riprap protection is proposed at the upstream end of the channel modification in Robinson's Branch and between the Elizabeth Ave. and Rail Road Bridges in the Rahway River.

There are also approximately 1,350 ft. of levees and 4,000 ft. of floodwalls included in this plan. These levees and floodwalls were divided into three systems. The Robinson's Branch right bank, System 1 extends from high ground near W Milton Ave. down to St. Georges Ave. (approx. 1,300 ft. of levee/floodwall) and System 2 extends a short distance from Hamilton St. to Irving St. (approx.150 ft. of floodwall). The Robinson's Branch left bank, System 3 extends from New Church St. downstream to high ground on the right bank of the Rahway river near Whittier St. (approx. 3,900 ft. of levee/floodwall). Other features included in this plan are four road closure gates located at Central Ave, Hamilton St., Irving St. and W Gran Ave., and two ponding areas located near Hamilton St. and near Allen St. See Figure 40 for plan view details.

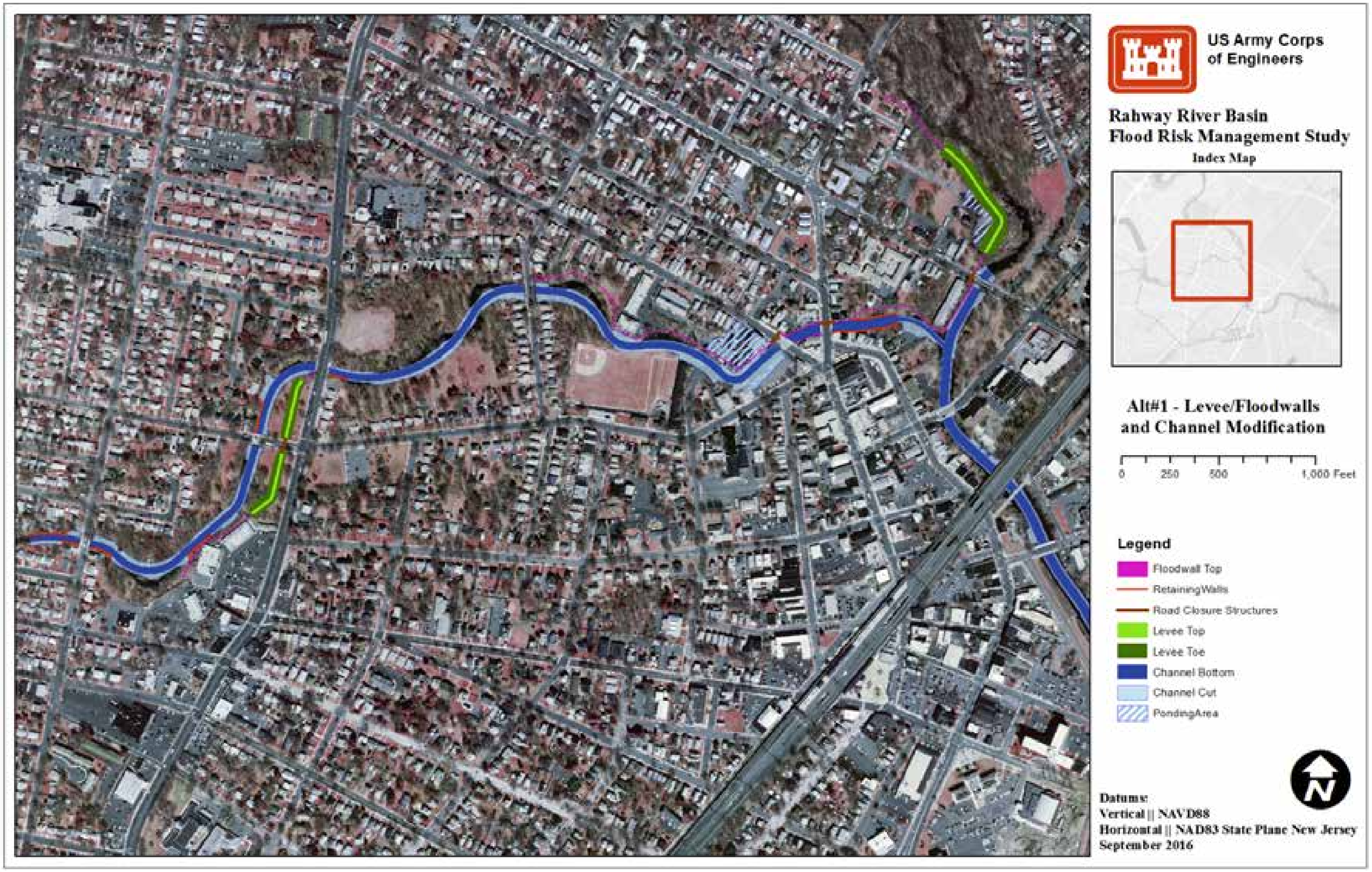

Figure 40: Alternative #1 for the Robinson's Branch.

4.5.2 *Alternative #2:*

Several analyses were performed for the Middlesex Reservoir, on Robinson's Branch: a combination with several new outlet pipes/gate, operation before and during the storm event, and spillway modification. All the analyzed plans resulted with a low performance of flood risk reduction in the Robinson's Branch. This is due to several reasons:

(1) Rahway River Flood - Backwater from the Rahway River prevents a reduction in flooding for much of the Robinson's Branch.
(2) Lack of storage capacity – Assuming a drawdown of half the capacity of the reservoir, the storage capacity would be approximately 200 ac-ft., which is the volume between elevations 42.9 ft. NAVD 88 to 38.0 ft. NAVD 88 (reservoir half full). This is not enough to significantly reduce flood risk.

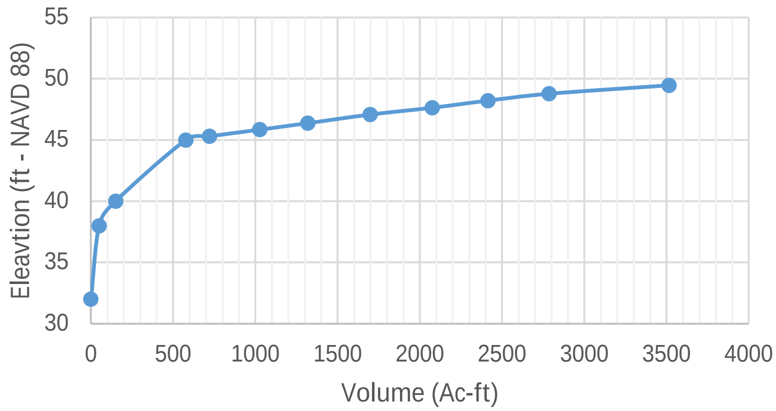

Figure 41: Estimated storage – elevation in Middlesex Reservoir.

There are other disadvantages with the plan:

(1) Additional storage will delay the peak flow in Robinson's Branch making it more coincidental with the Rahway River peak flow. This might result in higher WSE at the confluence with the Rahway River.
(2) Complex operation of gates.
(3) Possible induced flooding upstream or downstream due to uncertainty in the storm event prediction and the associated operation of the dam.
(4) High cost associated with the dam modification and possible replacement.

Due to the low performance and significant disadvantages there was no further analysis on the Middlesex Reservoir. Similar results were concluded during the 1980's Robinson's Branch analysis.

4.5.3 Alternative #3:

This alternative consists of non-structural treatments for structures within the 1% and 10% chance of annual exceedance (100-yr and 10-yr) floodplains of Robinson's Branch and the Rahway River in Clark. Nonstructural Flood Proofing measures considered in this project were:

- Dry Flood Proofing. Dry flood proofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure walls. Dry flood proofing measures considered in this screening make the portion of a building that is below the flood level watertight through attaching watertight closures to the structure in doorway and window openings.
- Wet Flood Proofing. Wet flood proofing measures allow flood water to get inside lower, non-living space areas of the structure via vents and openings in order to reduce the effects of hydrostatic pressure and, in turn, reduce flood-related damages to the structure's foundation.
- *Elevation (aka. Raise)*. Elevation involves raising the lowest finished floor of a building to a height that is above the flood level. In some cases, the structure is lifted in place and foundation walls are extended up to the new level of the lowest floor.
- *Buyouts*. It involves the purchase and elimination of flood damaged structures, allowing owners to move to places away from flood risk.

A structural measure of barriers was also considered:

- *Barriers (aka. Ringwall)*. Barriers such as ringwalls, levees, or berms generally surround the building but are not attached. It is used where the elevation isn't practical or feasible.

Non-structural measures were evaluated for approximately 430 structures contained in the 1% annual exceedance (100-yr event) flood inundation area and approximately 90 structures contained in the 10% annual exceedance (10-yr event) flood inundation area for the Robinson's Branch and the Rahway River in Clark, NJ, respectively. All structures will be treated to an elevation of one foot above the 1% annual exceedance event. The structures to be treated in the non-structural plan for the 10% and 1% annual exceedance events are summarized in Table 9 and shown in Figure 42.

Table 9: Number of structures treated for Rahway River at Robinson's Branch non-structural plan for the 10% and 1% annual exceedance events.

Nonstructural Flood Proofing Measure	10% Annual Exceedance (10-yr)			1% Annual Exceedance (100-yr)		
	Residential	**Non-Residential**	**Total**	**Residential**	**Non-Residential**	**Total**
Dry Flood proofing	0	0	0	11	7	18
Wet Flood proofing	1	1	2	2	3	5
Barriers	2	4	6	3	10	13
Raise	13	0	13	188	0	188
Buyout	0	0	0	0	0	0
Total of Structures	16	5	**21**	204	20	**224**

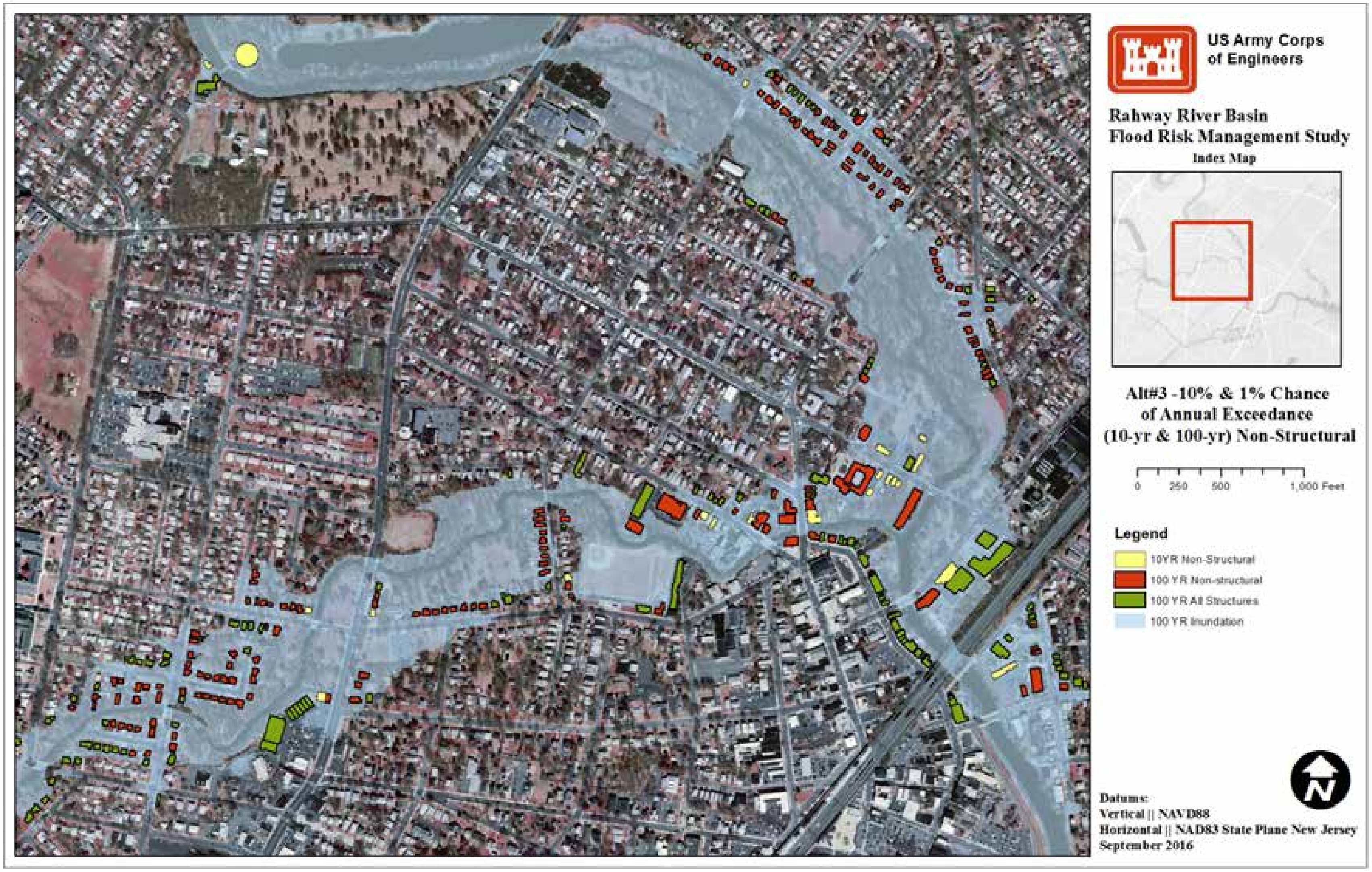

Figure 42: 10% and 1% chance of annual exceedance non-structural alternative in Cranford Township.

5.0 UNCERTAINTY ANALYSIS ON EXISTING AND FUTURE WITH AND WITHOUT PROJECT CONDITIONS

The steady and unsteady analyses required a different approach to estimate the uncertainty. Initially, the uncertainty in the computed WSEs was evaluated by conducting a sensitivity analysis. The goal was to develop realistic upper and lower uncertainty bands on the computed stage for a given discharge. The hydraulic characteristics considered in developing the upper and lower bounds were the Manning's n-value, debris jams at bridges, weir coefficients and gate openings at the existing weirs. A 20% reduction and a 40% increase to the n-values were assigned to help bracket the upper and lower uncertainty bands. This was applied to the majority of cross sections in the hydraulic model. For improved conditions in dam/reservoirs alternatives, 10% decrease in storage capacity and obstruction in spillways and orifices were assumed. The average value was computed per reach and the upper and the lower stages for each frequency were be provided to economics. The average value for most of the reaches between the upper and lower bands it was below 2.0 ft. As a result a standard deviation of 0.5 ft. was used as the method and minimum uncertainty value. As the model developed from a steady and unsteady hybrid hydraulic model to a full unsteady model it became evident that the flow years of record would sufficed to create an acceptable upper and lower uncertainty bands. In addition, the North Atlantic Coast Comprehensive Study uncertainty bands for Rahway at mouth (node ID: 11659), were used for the downstream boundary conditions. The uncertainty boundary are in compliance with the recommended procedure provided in the EM 1110-2-1619 (USACE 1996).

Draft Appendix D

Cost Engineering

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

APPENDIX D – COST ENGINEERING

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COST ENGINEERING

PROECT BACKGROUND

C1. This appendix presents the detail cost estimates for Alternative 4a and the 10-Year Nonstructural treatment in the Robinsons Branch located in northeastern New Jersey. Alternative 4a encompasses portions of Cranford/Upstream area. It consists of modification of dam to ensure it meets Corps dam safety standards. It also includes the 8,930 LF of channel improvement. The first cost for alternative 4a and the 10-Year Nonstructural alternative is presented in Table C1 and C2. Note that the real estate cost for both alternatives are currently a placeholder.

Table C1 – First Cost Table for Alternative 4a

Rahway River (Fluvial) - Alternative 4a
October 2015 Price Level

Storm Risk Management Feasibility Study

Feat. Acct.	Description	Qty	UoM	Subtotal	Cont. %	Cont $$	Total Cost
	Alternative 4a						
01	Lands & Damages			$ 2,354,098	15.54%	$ 365,820	$ 2,719,918
	Total Lands & Damages			**$ 2,354,098**		**$ 365,820**	**$ 2,719,918**
03	Reservoirs			$ 33,339,038	48.05%	$ 16,019,408	$ 49,358,445
	Total Reservoirs			**$ 33,339,038**		**$ 16,019,408**	**$ 49,358,445**
06	Fish & Wildlife Facilities	1	LS	$ 4,268,669	29.62%	$ 1,264,380	$ 5,533,049
	Total Fish & Wildlife Facilities			**$ 4,268,669**		**$ 1,264,380**	**$ 5,533,049**
09	Channels & Canals	1	LS	$ 1,718,636	25.93%	$ 445,642	$ 2,164,279
	Total Channels & Canals			**$ 1,718,636**		**$ 445,642**	**$ 2,164,279**
18	Cultural Resource Preservation	1	LS	$ 1,250,000	26.09%	$ 326,125	$ 1,576,125
	Total Cultural Resource Preservation			**$ 1,250,000**		**$ 326,125**	**$ 1,576,125**
30	Planning, Engineering, and Design	1	LS	$ 4,059,000	18.50%	$ 750,915	$ 4,809,915
31	Construction Management	1	LS	$ 2,999,000	13.64%	$ 409,064	$ 3,408,064
	Total Alternative #4a			**$ 49,988,441**		**$ 19,581,353**	**$ 69,569,795**

Table C2 – First Cost Table for 10-Year Nonstructural Alternative

Rahway River (Fluvial): 10-Year Nonstructural

October 2015 Price Level

Storm Risk Management Feasibility Study

Feat. Acct.	Description	Qty	UoM	Subtotal	Cont. %	Cont $$	Total Cost
	10-Year Nonstructural						
01	Lands & Damages			$ 404,566	20.00%	$ 80,913	$ 485,479
	Total Lands & Damages			**$ 404,566**		**$ 80,913**	**$ 485,479**
18	Cultural Resource Preservation			$ 1,200,000	26.47%	$ 317,659	$ 1,517,659
	Total Cultural Resource Preservation			**$ 1,200,000**		**$ 317,659**	**$ 1,517,659**
19	Buildings, Grounds & Utilities	1	LS	$ 5,450,791	30.94%	$ 1,686,674	$ 7,137,465
	Total Buildings, Grounds & Utilities			**$ 5,450,791**		**$ 1,686,674**	**$ 7,137,465**
30	Planning, Engineering, and Design	1	LS	$ 398,000	10.00%	$ 39,800	$ 437,800
31	Construction Management	1	LS	$ 400,000	10.00%	$ 40,000	$ 440,000
	Total 10-Year Nonstructural			**$ 7,853,357**		**$ 2,165,046**	**$ 10,018,403**

BASIS OF COST

C2. The construction cost estimate was developed in MCACES, Second Generation (MII) using the appropriate Work Breakdown Structure (WBS) and based on current estimated quantities provided by the Hydraulics & Hydrology, Civil, and Structural Engineers. The cost estimate was developed from these quantities using cost resources such as RSMeans, historical data from similar construction features, and MII Cost Libraries. The contingencies were developed based on input to the Abbreviated Cost Schedule Risk Analysis (ARA) (template provided by the Cost Mandatory Center of Expertise, MCX, Walla Walla District). These contingencies were applied to the construction cost estimates to develop the Total Project First Cost. The construction duration for alternative 4a and the 10-Year nonstructural alternative was estimated at 42 months and 9 months respectively, as shown in Figure C3 and C4 on page C11 and C12. The construction schedule was developed based on the crew outputs referenced from RSMeans with the assumption that multiple crews would work simultaneously.

CONTINGENCIES

C3. As stated in ER 1110-2-1302, the goal in contingency development is to identify the uncertainty associated with an item of work or task to an acceptable degree of confidence. Consideration must be given to the detail available at each stage of planning, design, or construction for which a cost estimate is being prepared. Contingency may vary throughout the cost estimate and could constitute a significant portion of the overall costs when data or design details are unavailable. Final contingency development and assessment of the potential for cost growth is included in this cost estimate. To develop the Total Project First Cost, contingencies developed in the ARA were applied. The contingency factors used in alternative 4a and the 10-year nonstructural alternative are summarized in Table C3 and C4.

Table C3 – Alternative 4a Contingency Factors

Element	Contingency Factor
Reservoirs	48.05%
Fish and Wildlife Facilities	29.62%
Channels	25.93%
Cultural Resource Preservation	26.09%
Total Construction Contingency	**45.18%**
Lands & Damages	15.54%
Planning, Engineering, and Design	18.50%
Construction Management	13.64%

Table C4 – 10-Year Nonstructural Contingency Factors

Element	Contingency Factor
Cultural Resource Preservation	26.47%
Buildings, Grounds & Utilities	30.94%
Total Construction Contingency	**30.14%**
Lands & Damages	20.00%
Planning, Engineering, and Design	10.00%
Construction Management	10.00%

PLANNING, ENGINEERING AND DESIGN

C4. The costs were developed for all activities associated with the planning, engineering and design effort. The cost for this account includes the preparation of Design Documentation Reports and plans and specifications for each construction contract and engineering support during construction through project completion. It includes all the in-house labor based upon work-hour requirements, material and facility costs, travel and overhead. The percentage breakout in the Total Project Cost Summary (TPCS), as show in Figure C1 and C2, was developed based on input from respective offices in accordance with the CWBS.

CONSTRUCTION MANAGEMENT

C5. The costs were developed for all construction management activities from pre-award requirements through final contract closeout. These costs include the in-house labor based upon work-hour requirements, materials, facility costs, support contracts, travel and overhead. Costs were developed based on the input from the construction division in accordance with the CWBS and include but are not limited to anticipated items such as the salaries of the resident engineer and staff, survey men, inspectors, draftsmen, clerical, and custodial personnel; operation, maintenance and fixed charges for transportation and for other field equipment; field supplies; construction management, general construction supervision; project office administration, distributive cost of area office and general overhead charged to the project. The work items and activities would include, but not be limited to: the salaries of all supervisory, engineering (including resident geologist and geological staff), office and safety field personnel; all on site expenses.

INTEREST DURING CONSTRUCTION

C6. Interest during construction (IDC) is the cost of construction money invested before the beginning of the period of economic analysis and before the accumulation of benefits by the project. IDC costs have been added to the project cost to determine investment costs. Average annual costs were determined based on investment costs which include IDC. The pre-base year costs were estimated using the Federal interest rate of 3.125 percent (FY16).

OPERATION AND MAINTENANCE

C7. The Operation and Maintenance (O&M) costs were estimated to represent the anticipated annual costs necessary to maintain the project at full operating efficiency throughout the project life. Following completion of the project, operation and maintenance of project facilities would be performed by the local cooperating agency in accordance with federal regulations and operations manual.

ESTIMATED ANNUAL CHARGES

C8. Annualized costs are based on an economic project life of 50 years and an interest rate of 3.125%. The annual charges include the annualized investment costs along with annual operation and maintenance costs. A detailed breakdown of annual costs for alternative 4a and the 10-Year Nonstructural alternative is presented in Table C5 and Table C6 respectively.

Table C5 – Estimated Alternative 4a Annual Charges

Rahway River Watershed Cranford - Alt. 4a

First Cost	$	69,570,000
Sunk Cost	$	-
Investment Cost		
Interest During Construction (a)	$	3,790,418
Total Investment Cost:	$	73,360,418
Annual Costs		
Annualized Investment Cost (b)	$	2,919,228
Annualized Operation & Maintenance Cost (c)	$	258,000
Total Annual Cost*	**$**	**3,177,228**

*October 2015 Price Level

(a) Based on 42 months of construction @ 3.125% (IDC, E&D and RE costs calculated separately and included in this total)

(b) Annualized investment cost only includes the remaining features.
I = 3.125% and n = 50 yrs

(c) Assume 0.5% of total construction first cost for Reservoirs and Channels & Canals case on historical data.

Table C6 – Estimated 10-Year Nonstructural Annual Charges

Rahway River Watershed Robinson's Branch 10 YR Non-Structural Alt.

First Cost	$	10,018,403
Sunk Cost		
Investment Cost		
Interest During Construction (a)	$	103,512
Total Investment Cost:	$	10,121,914
Annual Costs		
Annualized Investment Cost (b)	$	402,781
Total Annual Cost*	**$**	**402,781**

*October 2015 Price Level

(a) Based on 9 months of construction @ 3.125% (IDC, E&D and RE costs calculated separately and included in this total)

(b) Annualized investment cost only includes the remaining features.
I = 3.125% and n = 50 yrs

COST SUMMARY

The Total Fully Funded Project cost for Alternative 4a and the 10-Year Nonstructural alternative is $78,157,000 and $10,997,000 respectively. This cost is 65% federally funded and 35% non-federally funded.

Figure C1 – Total Project Cost Summary for Alternative 4a

PROJECT: **Rahway River Watershed Cranford - Alt. 4a**
PROJECT NO: P2 xxxxxx
LOCATION: Union County, NJ

DISTRICT: NAN New York **PREPARED: 5/19/2016**
POC: CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.

This Estimate reflects the scope and schedule in report; Flood Risk Management Study

Program Year (Budget EC): 2017
Effective Price Level Date: 1 OCT 16

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 6/1/2016 ($K)	TOTAL FIRST COST ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
03	RESERVOIRS	$33,339	$16,019	48.05%	$49,358	1.8%	$33,928	$16,302	$50,231	$0	$50,231	10.2%	$37,394	$17,968	$55,362
06	FISH & WILDLIFE FACILITIES	$4,269	$1,264	29.62%	$5,533	1.8%	$4,344	$1,287	$5,631	$0	$5,631	10.2%	$4,788	$1,418	$6,206
09	CHANNELS & CANALS	$1,719	$446	25.93%	$2,164	1.8%	$1,749	$454	$2,203	$0	$2,203	10.2%	$1,928	$500	$2,428
18	CULTURAL RESOURCE PRESERVATION	$1,250	$326	26.09%	$1,576	1.8%	$1,272	$332	$1,604	$0	$1,604	10.2%	$1,402	$366	$1,768
	CONSTRUCTION ESTIMATE TOTALS:	$40,576	$18,056		$58,632	1.8%	$41,293	$18,375	$59,668	$0	$59,668	10.2%	$45,512	$20,252	$65,764
01	LANDS AND DAMAGES	$2,354	$366	15.54%	$2,720	1.8%	$2,396	$372	$2,768	$0	$2,768	6.5%	$2,551	$396	$2,947
30	PLANNING, ENGINEERING & DESIGN	$4,059	$751	18.50%	$4,810	3.6%	$4,205	$778	$4,983	$0	$4,983	14.3%	$4,805	$889	$5,694
31	CONSTRUCTION MANAGEMENT	$2,999	$409	13.64%	$3,408	1.8%	$3,053	$416	$3,469	$0	$3,469	8.1%	$3,301	$450	$3,752
	PROJECT COST TOTALS:	$49,988	$19,581	39.17%	$69,570		$50,947	$19,941	**$70,889**	$0	**$70,889**	10.3%	$56,169	$21,987	$78,157

______________ **CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.**

______________ **PROJECT MANAGER, RIFAT SALIM**

______________ **CHIEF, REAL ESTATE, NOREEN DRI**

______________ **CHIEF, PLANNING**

______________ **CHIEF, ENGINEERING**

______________ **CHIEF, OPERATIONS**

______________ **CHIEF, CONSTRUCTION**

______________ **CHIEF, CONTRACTING**

______________ **CHIEF, PM-PB**

______________ **CHIEF, DPM**

ESTIMATED FEDERAL COST: **65%** **$50,802**
ESTIMATED NON-FEDERAL COST: **35%** **$27,355**

ESTIMATED TOTAL PROJECT COST: **$78,157**

PROJECT: Rahway River Watershed Cranford - Alt. 4a
LOCATION: Union County, NJ
This Estimate reflects the scope and schedule in report; Flood Risk Management Study

DISTRICT: NAN New York PREPARED: 5/19/2016
POC: CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			18-May-16	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 1 or CONTRACT 1													
03	RESERVOIRS	$33,339	$16,019	48.05%	$49,358	1.8%	$33,928	$16,302	$50,231	2022Q1	10.2%	$37,394	$17,968	$55,362
06	FISH & WILDLIFE FACILITIES	$4,269	$1,264	29.62%	$5,533	1.8%	$4,344	$1,287	$5,631	2022Q1	10.2%	$4,788	$1,418	$6,206
09	CHANNELS & CANALS	$1,719	$446	25.93%	$2,164	1.8%	$1,749	$454	$2,203	2022Q1	10.2%	$1,928	$500	$2,428
18	CULTURAL RESOURCE PRESERVATION	$1,250	$326	26.09%	$1,576	1.8%	$1,272	$332	$1,604	2022Q1	10.2%	$1,402	$366	$1,768
	CONSTRUCTION ESTIMATE TOTALS:	$40,576	$18,056	44.50%	**$58,632**		$41,293	$18,375	$59,668			$45,512	$20,252	$65,764
01	LANDS AND DAMAGES	$2,354	$366	15.5%	$2,720	1.8%	$2,396	$372	$2,768	2020Q2	6.5%	$2,551	$396	$2,947
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$609	$113	18.50%	$722	3.6%	$631	$117	$748	2020Q2	13.6%	$717	$133	$849
1.0%	Planning & Environmental Compliance	$406	$75	18.50%	$481	3.6%	$421	$78	$498	2020Q2	13.6%	$478	$88	$566
3.5%	Engineering & Design	$1,420	$263	18.50%	$1,683	3.6%	$1,471	$272	$1,743	2020Q2	13.6%	$1,671	$309	$1,980
0.5%	Reviews, ATRs, IEPRs, VE	$203	$38	18.50%	$241	3.6%	$210	$39	$249	2020Q2	13.6%	$239	$44	$283
0.5%	Life Cycle Updates (cost, schedule, risks)	$203	$38	18.50%	$241	3.6%	$210	$39	$249	2020Q2	13.6%	$239	$44	$283
0.5%	Contracting & Reprographics	$203	$38	18.50%	$241	3.6%	$210	$39	$249	2020Q2	13.6%	$239	$44	$283
1.5%	Engineering During Construction	$609	$113	18.50%	$722	3.6%	$631	$117	$748	2021Q1	17.0%	$738	$137	$875
0.5%	Planning During Construction	$203	$38	18.50%	$241	3.6%	$210	$39	$249	2021Q1	17.0%	$246	$46	$292
0.5%	Project Operations	$203	$38	18.50%	$241	3.6%	$210	$39	$249	2020Q2	13.6%	$239	$44	$283
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$2,029	$277	13.64%	$2,306	1.8%	$2,066	$282	$2,347	2021Q1	8.1%	$2,234	$305	$2,538
1.2%	Project Operation:	$487	$66	13.64%	$553	1.8%	$496	$68	$563	2021Q1	8.1%	$536	$73	$609
1.2%	Project Management	$483	$66	13.64%	$549	1.8%	$492	$67	$559	2021Q1	8.1%	$532	$73	$604
	CONTRACT COST TOTALS:	$49,988	$19,581		$69,570		$50,947	$19,941	$70,889			$56,169	$21,987	$78,157

Figure C2 – Total Project Cost Summary for 10-Year Nonstructural Alternative

PROJECT: Rahway River Watershed Robinson's Branch 10 YR Non-Structural Alt.
PROJECT NO: P2 xxxxxx
LOCATION: Union County, NJ

DISTRICT: NAN New York PREPARED: 5/19/2016
POC: CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.

This Estimate reflects the scope and schedule in report; Flood Risk Management Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2017 Effective Price Level Date: 1 OCT 16									
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 8/1/2016 ($K)	TOTAL FIRST COST ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
18	CULTURAL RESOURCE PRESERVATION	$1,200	$318	26.47%	$1,518	1.8%	$1,221	$323	$1,544	$0	$1,544	7.5%	$1,313	$348	$1,661
19	BUILDINGS, GROUNDS & UTILITIES	$5,451	$1,687	30.94%	$7,137	1.8%	$5,547	$1,716	$7,264	$0	$7,264	7.5%	$5,965	$1,846	$7,811
	CONSTRUCTION ESTIMATE TOTALS:	$6,651	$2,004		$8,655	1.8%	$6,768	$2,040	$8,808	$0	$8,808	7.5%	$7,278	$2,193	$9,472
01	LANDS AND DAMAGES	$405	$81	20.00%	$485	1.8%	$412	$82	$494	$0	$494	6.5%	$438	$88	$526
30	PLANNING, ENGINEERING & DESIGN	$398	$40	10.00%	$438	3.6%	$412	$41	$454	$0	$454	14.0%	$470	$47	$517
31	CONSTRUCTION MANAGEMENT	$400	$40	10.00%	$440	1.8%	$407	$41	$448	$0	$448	7.6%	$438	$44	$482
	PROJECT COST TOTALS:	$7,853	$2,165	27.57%	$10,018		$8,000	$2,204	$10,204	$0	$10,204	7.8%	$8,625	$2,372	$10,997

CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.

PROJECT MANAGER, RIFAT SALIM

CHIEF, REAL ESTATE, NOREEN

CHIEF, PLANNING

CHIEF, ENGINEERING

CHIEF, OPERATIONS

CHIEF, CONSTRUCTION

CHIEF, CONTRACTING

CHIEF, PM-PB

CHIEF, DPM

ESTIMATED FEDERAL COST:	65%	$7,148
ESTIMATED NON-FEDERAL COST:	35%	$3,849
ESTIMATED TOTAL PROJECT COST:		**$10,997**

PROJECT: Rahway River Watershed Robinson's Branch 10 YR Non-Structural Alt.
LOCATION: Union County, NJ
This Estimate reflects the scope and schedule in report; Flood Risk Management Study

DISTRICT: NAN New York
POC: CHIEF, COST ENGINEERING, MUKESH KUMAR, P.E.
PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			18-May-16	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
18	CULTURAL RESOURCE PRESERVATION	$1,200	$318	26.47%	$1,518	1.8%	$1,221	$323	$1,544	2020Q4	7.5%	$1,313	$348	$1,661
19	BUILDINGS, GROUNDS & UTILITIES	$5,451	$1,687	30.94%	$7,137	1.8%	$5,547	$1,716	$7,264	2020Q4	7.5%	$5,965	$1,846	$7,811
	CONSTRUCTION ESTIMATE TOTALS:	$6,651	$2,004	30.14%	**$8,655**		$6,768	$2,040	$8,808			$7,278	$2,193	$9,472
01	LANDS AND DAMAGES	$405	$81	20.00%	$485	1.8%	$412	$82	$494	2020Q2	6.5%	$438	$88	$526
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$67	$7	10.00%	$74	3.6%	$69	$7	$76	2020Q2	13.6%	$79	$8	$87
0.5%	Planning & Environmental Compliance	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q2	13.6%	$39	$4	$43
1.5%	Engineering & Design	$100	$10	10.00%	$110	3.6%	$104	$10	$114	2020Q2	13.6%	$118	$12	$129
0.5%	Reviews, ATRs, IEPRs, VE	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q2	13.6%	$39	$4	$43
0.5%	Life Cycle Updates (cost, schedule, risks)	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q2	13.6%	$39	$4	$43
0.5%	Contracting & Reprographics	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q2	13.6%	$39	$4	$43
0.5%	Engineering During Construction	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q4	15.9%	$40	$4	$44
0.5%	Planning During Construction	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q4	15.9%	$40	$4	$44
0.5%	Project Operations	$33	$3	10.00%	$36	3.6%	$34	$3	$38	2020Q2	13.6%	$39	$4	$43
31	CONSTRUCTION MANAGEMENT													
4.0%	Construction Management	$266	$27	10.00%	$293	1.8%	$271	$27	$298	2020Q4	7.6%	$291	$29	$321
1.0%	Project Operation:	$67	$7	10.00%	$74	1.8%	$68	$7	$75	2020Q4	7.6%	$73	$7	$81
1.0%	Project Management	$67	$7	10.00%	$74	1.8%	$68	$7	$75	2020Q4	7.6%	$73	$7	$81
	CONTRACT COST TOTALS:	$7,853	$2,165		$10,018		$8,000	$2,204	$10,204			$8,625	$2,372	$10,997

Figure C3 – Construction Schedule for Alternative 4A

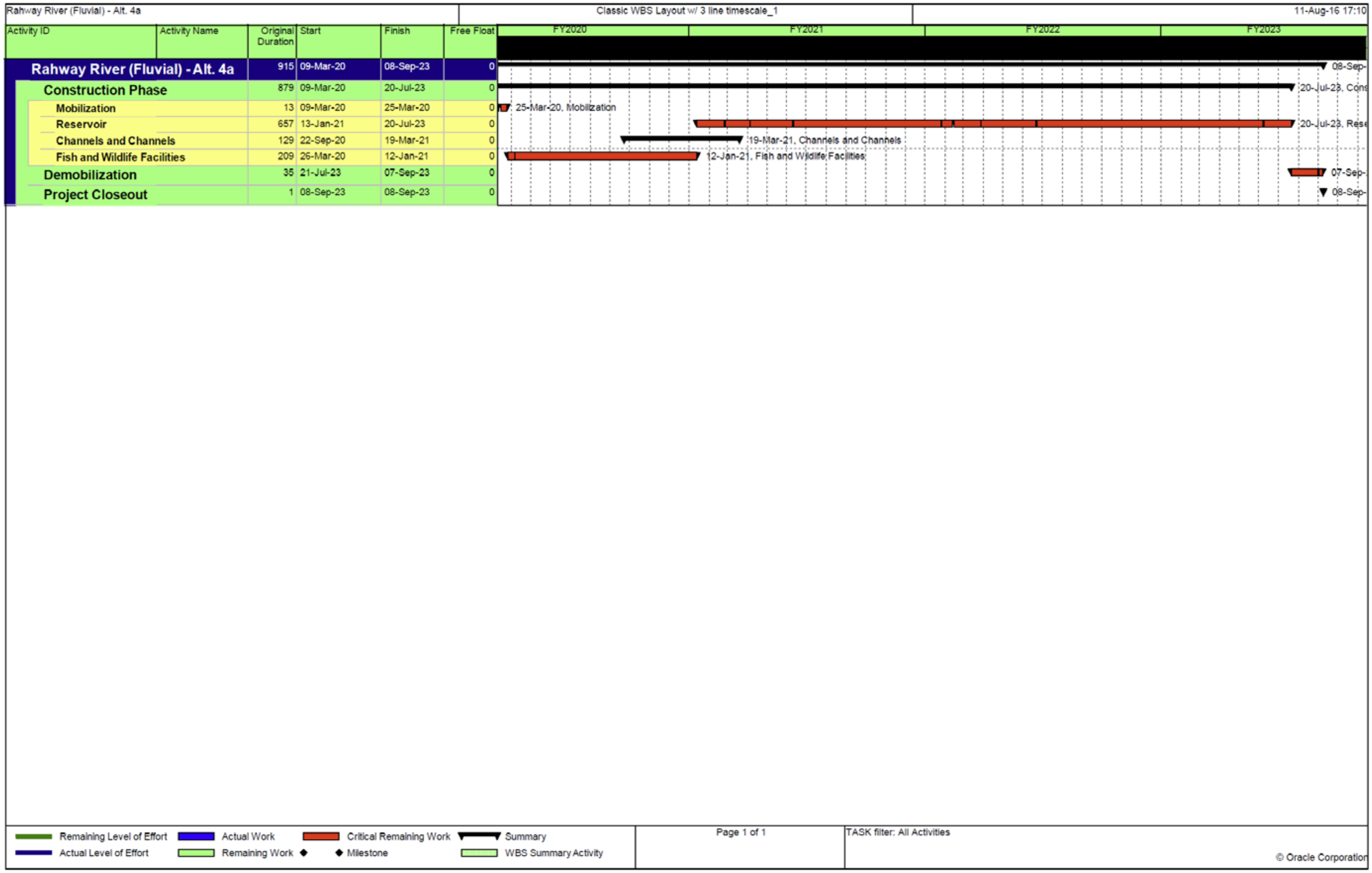
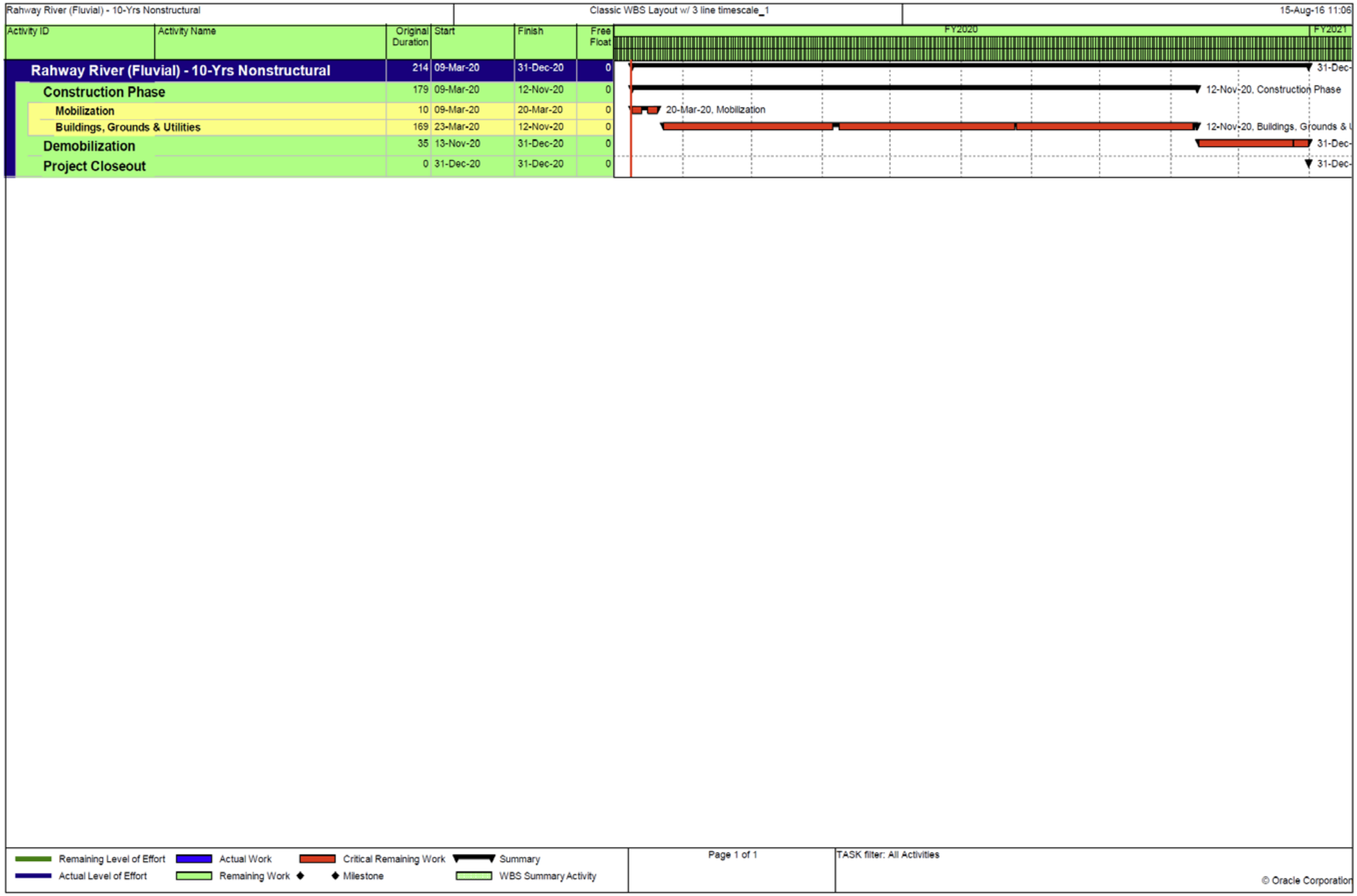


Figure C4 – Construction Schedule for 10-Year Nonstructural Alternative



Activity ID	Activity Name	Original Duration	Start	Finish	Free Float
Rahway River (Fluvial) - 10-Yrs Nonstructural		214	09-Mar-20	31-Dec-20	0
Construction Phase		179	09-Mar-20	12-Nov-20	0
Mobilization		10	09-Mar-20	20-Mar-20	0
Buildings, Grounds & Utilities		169	23-Mar-20	12-Nov-20	0
Demobilization		35	13-Nov-20	31-Dec-20	0
Project Closeout		0	31-Dec-20	31-Dec-20	0

Figure C5 – Abbreviated Risk Analysis: Alternative 4a

Abbreviated Risk Analysis

Project (less than $40M): **Project Example** — **Alternative: Structural Plan**

Project Development Stage/Alternative: **Alternative Formulation**

Risk Category: **Low Risk: Typical Construction, Simple** — **Meeting Date: 5/4/2016**

Total Estimated Construction Contract Cost = $ 40,576,343

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 7,022,000		25.00%	$ 1,755,500	$ 8,777,500
1	03 RESERVOIRS	Orange Reservoir	$ 33,339,038		48.05%	$ 16,019,629	$ 49,358,667
2	06 FISH AND WILDLIFE FACILITIES	Environmental Mitigation	$ 4,268,669		29.62%	$ 1,264,542	$ 5,533,211
3	09 01 CHANNELS	Channel Cut and Fill	$ 1,718,636		25.93%	$ 445,604	$ 2,164,240
4	18 CULTURAL RESOURCE PRESERVATION	Cultural Resource Mitigation	$ 1,250,000		26.09%	$ 326,082	$ 1,576,082
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	Remaining Construction Items	$ -	0.0%	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 3,763,000		18.50%	$ 696,116	$ 4,459,116
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 2,782,000		13.64%	$ 379,496	$ 3,161,496
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals

	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 7,022,000	25.00%	$ 1,755,500	$ 8,777,500.00
Total Construction Estimate	$ 40,576,343	44.50%	$ 18,055,856	$ 58,632,199
Total Planning, Engineering & Design	$ 3,763,000	18.50%	$ 696,116	$ 4,459,116
Total Construction Management	$ 2,782,000	13.64%	$ 379,496	$ 3,161,496
Total Excluding Real Estate	**$ 47,121,343**	**41%**	**$ 19,131,468**	**$ 66,252,811**

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$47,121k	$58,600k	$66,253k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Project Example Structural Plan

Alternative Formulation

Abbreviated Risk Analysis

Meeting Date: 4-May-16

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Management & Scope Growth				Maximum Project Growth		40%
PS-1	Orange Reservoir	• Potential for scope growth, added features?	The current estimate presents a complete replacement of the reservoir dam. A change of scope is highly unlikely.	Marginal	Unlikely	0
PS-2	Environmental Mitigation	• Potential for scope growth, added features?	All resource agencies will require additional mitigation in addition to what has been assumed.	Moderate	Likely	3
PS-3	Channel Cut and Fill	• Potential for scope growth, added features?	During optimization the width of the channel may change.	Marginal	Possible	1
PS-4	Cultural Resource Mitigation	• Potential for scope growth, added features?	Lack of data and coordination with resource agency. Previous experience with similar elements.	Marginal	Likely	2
PS-5	0			Negligible	Possible	0
PS-6	0			Negligible	Unlikely	0
PS-7	0			Negligible	Unlikely	0
PS-8	0			Negligible	Unlikely	0
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0
PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	• Potential for scope growth, added features?	No major changes are expected in scope causing negligible impacts.	Negligible	Unlikely	0
PS-14	Construction Management	• Potential for scope growth, added features?	No major changes are expected in scope causing negligible impacts.	Negligible	Unlikely	0

Acquisition Strategy				Maximum Project Growth		30%
AS-1	Orange Reservoir	• Accelerated schedule or harsh weather schedule? • Limited bid competition anticipated?	The project construction is limited to outside of rain season. Accelerated construction schedule may be required by the contractor in order to meet this construction window. A specialized contractor may be required for the construction of the dam.	Moderate	Possible	2
AS-2	Environmental Mitigation	• Limited bid competition anticipated?	Contractors are plentiful within this project region	Marginal	Unlikely	0
AS-3	Channel Cut and Fill	• Limited bid competition anticipated?	Contractors are plentiful within this project region	Marginal	Unlikely	0
AS-4	Cultural Resource Mitigation	• Limited bid competition anticipated?	Contractors are plentiful within this project region	Marginal	Unlikely	0
AS-5	0			Marginal	Unlikely	0
AS-6	0			Negligible	Unlikely	0
AS-7	0			Negligible	Unlikely	0
AS-8	0			Negligible	Unlikely	0
AS-9	0			Negligible	Unlikely	0
AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	• Limited bid competition anticipated?	Contractors are plentiful within this project region	Negligible	Unlikely	0
AS-14	Construction Management	• Limited bid competition anticipated?	Contractors are plentiful within this project region	Negligible	Unlikely	0
Construction Elements				**Maximum Project Growth**		**15%**
CON-1	Orange Reservoir	• Accelerated schedule or harsh weather schedule? • High risk or complex construction elements, site access, in-water? • Water care and diversion plan? • Unique construction methods? • Potential for construction modification and claims?	The project construction is limited to outside of rain season. Accelerated construction schedule may be required by the contractor in order to meet this construction window. A specialized contractor may be required for the construction of the dam. The current plan assumes the drainage of the reservoir. A plan must be in place to ensure the uninterrupted flow of the river even during rain events.	Significant	Likely	4
CE-2	Environmental Mitigation	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	Environmental windows restrictions on vegetation clearing will impact the construction schedule.	Negligible	Likely	1

CE-3	Channel Cut and Fill	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	Environmental channel work windows restrictions will impact the construction schedule.	Moderate	Likely	3
CE-4	Cultural Resource Mitigation	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	Project complexity of these items may impact construction bid, possible contract modifications.	Marginal	Likely	2
CE-5	0			Marginal	Possible	1
CE-6	0			Negligible	Unlikely	0
CE-7	0			Negligible	Unlikely	0
CE-8	0			Negligible	Unlikely	0
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	An accelerated schedule on the design stage would potentially cause modifications increasing the cost of engineering during construction.	Marginal	Likely	2
CE-14	Construction Management	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	An accelerated schedule on the design stage would potentially cause modifications.	Negligible	Possible	0
Specialty Construction or Fabrication				Maximum Project Growth		50%
SC-1	Orange Reservoir	• Confidence in constructibility or methodology?	There is limited experience in the construction of Dams within the district boundaries. A specialized contractor may be required.	Moderate	Possible	2
SC-2	Environmental Mitigation	• No concerns.		Negligible	Unlikely	0
SC-3	Channel Cut and Fill	• No concerns.		Negligible	Unlikely	0
SC-4	Cultural Resource Mitigation	• No concerns.		Negligible	Unlikely	0
SC-5	0			Negligible	Unlikely	0
SC-6	0			Negligible	Unlikely	0
SC-7	0			Negligible	Unlikely	0
SC-8	0			Negligible	Unlikely	0

SC-9	0			Negligible	Unlikely	0
SC-10	0			Negligible	Unlikely	0
SC-11	0			Negligible	Unlikely	0
SC-12	Remaining Construction Items	• No concerns.		Negligible	Unlikely	0
SC-13	Planning, Engineering, & Design	• No concerns.		Negligible	Unlikely	0
SC-14	Construction Management	• No concerns.		Negligible	Unlikely	0
Technical Design & Quantities					Maximum Project Growth	20%
T-1	Orange Reservoir	• Level of confidence based on design and assumptions? • Possibility for increased quantities due to loss, waste, or subsidence? • Sufficient investigations to develop quantities?	Quantities were developed based on existing drawing of the dam. As design evolves quantities on current project may change. No borings or foundation information is currently available.	Moderate	Very LIKELY	4
T-2	Environmental Mitigation	• Level of confidence based on design and assumptions?	As design evolves quantities on current project may change.	Negligible	Likely	1
T-3	Channel Cut and Fill	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	As design evolves quantities on current project may change. No borings or foundation information is currently available.	Marginal	Likely	2
T-4	Cultural Resource Mitigation	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	As design evolves quantities on current project may change. Archaeological surveys have not been carried out in the project area.	Negligible	Likely	1
T-5	0			Negligible	Likely	1
T-6	0			Negligible	Unlikely	0
T-7	0			Negligible	Unlikely	0
T-8	0			Negligible	Unlikely	0
T-9	0			Negligible	Unlikely	0
T-10	0			Negligible	Unlikely	0
T-11	0			Negligible	Unlikely	0
T-12	Remaining Construction Items			Negligible	Unlikely	0
T-13	Planning, Engineering, & Design	• Level of confidence based on design and assumptions?	As design evolves quantities on current project may change.	Negligible	Likely	1

T-14	Construction Management	• Level of confidence based on design and assumptions?	As design evolves quantities on current project may change.	Negligible	Likely	1
Cost Estimate Assumptions					Maximum Project Growth	25%
EST-1	Orange Reservoir	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances?	The estimate assumptions appear fairly optimistic given the locale. However productions may vary based on the work environment. I.E. river, accessibility, etc.	Marginal	Likely	2
EST-2	Environmental Mitigation	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances?	The estimate assumptions appear fairly optimistic given the locale. However productions may vary based on the work environment. I.E. river, accessibility, etc.	Marginal	Likely	2
EST-3	Channel Cut and Fill	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances?	The estimate assumptions appear fairly optimistic given the locale. However productions may vary based on the work environment. I.E. river, accessibility, etc.	Marginal	Likely	2
EST-4	Cultural Resource Mitigation	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances?	The estimate assumptions appear fairly optimistic given the locale. However productions may vary based on the work environment. I.E. river, accessibility, etc.	Marginal	Likely	2
EST-5	0	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion? • Overuse of Cost Book, lump sum, allowances?	The estimate assumptions appear fairly optimistic given the locale. However productions may vary based on the work environment. I.E. river, accessibility, etc.	Marginal	Likely	2
EST-6	0			Negligible	Unlikely	0
EST-7	0			Negligible	Unlikely	0
EST-8	0			Negligible	Unlikely	0
EST-9	0			Negligible	Unlikely	0
EST-10	0			Negligible	Unlikely	0
EST-11	0			Negligible	Unlikely	0
EST-12	Remaining Construction Items			Negligible	Unlikely	0
EST-13	Planning, Engineering, & Design	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion?	Estimate assumptions and resulting cost and risks could cause a revision to design and require further coordination.	Negligible	Likely	1
EST-14	Construction Management	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion?	Estimate assumptions would not impact the S&A efforts to any degree.	Negligible	Unlikely	0
External Project Risks					Maximum Project Growth	20%
EX-1	Orange Reservoir	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials? • Potential for market volatility impacting competition, pricing?	Adverse weather would impact the construction schedule. Fuel cost volatility has been an issue in recent years. The stakeholders have expressed concerns about how the project construction would limit the use of the reservoir.	Moderate	Likely	3
EX-2	Environmental Mitigation	• Political influences, lack of support, obstacles?	External project risks involves not having sufficient lands within project area to execute mitigation.	Moderate	Possible	2

EX-3	Channel Cut and Fill	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	Adverse weather would impact the construction schedule. Fuel cost volatility has been an issue in recent years.	Marginal	Possible	1
EX-4	Cultural Resource Mitigation	• Political influences, lack of support, obstacles?	A mitigation plan has not yet been developed. Coordination with the NJSHPO and local historical groups could influence the mitigation plan. Public concern for preservation of their historical district and historic properties.	Marginal	Likely	2
EX-5	0			Negligible	Unlikely	0
EX-6	0			Negligible	Unlikely	0
EX-7	0			Negligible	Unlikely	0
EX-8	0			Negligible	Unlikely	0
EX-9	0			Negligible	Unlikely	0
EX-10	0			Negligible	Unlikely	0
EX-11	0			Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	0
EX-13	Planning, Engineering, & Design	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	External risks such as political, funding sources, weather, and enivornmental windows could impact project costs over time. Changes to permitting and biological requirements could result in added coordination and design efforts.	Marginal	Possible	1
EX-14	Construction Management	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	External risks such as political, funding sources, weather, and enivornmental windows could impact project costs over time. Assuming design is 100% complete upon award, the only impact may be added coordination of external requirements occurring during course of construction and potential design changes resulting in modifications.	Marginal	Possible	1

Figure C6 – Abbreviated Risk Analysis: 10-Year Nonstructural

Abbreviated Risk Analysis

Project (less than $40M): **Project Example**
Project Development Stage/Alternative: **Alternative Formulation**
Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: **10 Year Non Structural Plan**
Meeting Date: **5/4/2016**

Total Estimated Construction Contract Cost = $ 6,650,791

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0.00%	$ -	$ -
1	19 BUILDINGS, GROUNDS, AND UTILITIES	10-Year Nonstructural	$ 5,450,791		30.94%	$ 1,686,674	$ 7,137,465
2	18 CULTURAL RESOURCE PRESERVATION	Cultural Resources Mitigation	$ 1,200,000		26.47%	$ 317,659	$ 1,517,659
3			$ -		0.00%	$ -	$ -
4			$ -		0.00%	$ -	$ -
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	Remaining Construction Items	$ -	0.0%	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ 399,047		20.47%	$ 81,698	$ 480,746
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 399,047		17.33%	$ 69,172	$ 468,219
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0.00%	$ -	$ -
Total Construction Estimate	$ 6,650,791	30.14%	$ 2,004,333	$ 8,655,124
Total Planning, Engineering & Design	$ 399,047	20.47%	$ 81,698	$ 480,746
Total Construction Management	$ 399,047	17.33%	$ 69,172	$ 468,219
Total Excluding Real Estate	$ 7,448,886	28.93%	$ 2,155,203	$ 9,604,089

	Base	50%	80%
Confidence Level Range Estimate ($000's)	$7,449k	$8,742k	$9,604k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Project Example 10 Year Non Structural Plan

Alternative Formulation

Abbreviated Risk Analysis

Meeting Date: 4-May-16

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Management & Scope Growth				Maximum Project Growth		40%
PS-1	10-Year Nonstructural	• Potential for scope growth, added features?	The proposed scope for the non structural alternative is very unlikely to change.	Moderate	Unlikely	1
PS-2	Cultural Resources Mitigation	• Potential for scope growth, added features?	The proposed scope for the non structural alternative is very unlikely to change.	Moderate	Unlikely	1
PS-3	0			Negligible	Unlikely	0
PS-4	0			Negligible	Unlikely	0
PS-5	0			Negligible	Unlikely	0
PS-6	0			Negligible	Unlikely	0
PS-7	0			Negligible	Unlikely	0
PS-8	0			Negligible	Unlikely	0
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0
PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	• Potential for scope growth, added features?	No major changes are expected in scope causing negligible impacts.	Negligible	Unlikely	0
PS-14	Construction Management	• Potential for scope growth, added features?	No major changes are expected in scope causing negligible impacts.	Negligible	Unlikely	0
Acquisition Strategy				Maximum Project Growth		30%

AS-1	10-Year Nonstructural	• Contracting plan firmly established? • 8a or small business likely? • Limited bid competition anticipated?	While there is no contracting plan in place yet, the current intent is to have each individual homeowner facilitate the work on their house/structure. The estimate has assumed subcontracting work on roughly 80% of the cost, so while there is a possibility that an acquisition strategy change will impact the project cost, is is assumed that the impact would be marginal at most.	Marginal	Possible	1
AS-2	Cultural Resources Mitigation	• Contracting plan firmly established? • 8a or small business likely? • Limited bid competition anticipated?	While there is no contracting plan in place yet, the current intent is to have each individual homeowner facilitate the work on their house/structure. The estimate has assumed subcontracting work on roughly 80% of the cost, so while there is a possibility that an acquisition strategy change will impact the project cost, is is assumed that the impact would be marginal at most.	Marginal	Possible	1
AS-3	0			Negligible	Unlikely	0
AS-4	0			Negligible	Unlikely	0
AS-5	0			Negligible	Unlikely	0
AS-6	0			Negligible	Unlikely	0
AS-7	0			Negligible	Unlikely	0
AS-8	0			Negligible	Unlikely	0
AS-9	0			Negligible	Unlikely	0

AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	• Limited bid competition anticipated?	While there is no contracting plan in place yet, the current intent is to have each individual homeowner facilitate the work on their house/structure. there is a possibility that an acquisition strategy change will impact the project cost, is is assumed that the impact would be marginal at most.	Marginal	Possible	1
AS-14	Construction Management	• Limited bid competition anticipated?	While there is no contracting plan in place yet, the current intent is to have each individual homeowner facilitate the work on their house/structure. there is a possibility that an acquisition strategy change will impact the project cost, is is assumed that the impact would be marginal at most.	Marginal	Possible	1
Construction Elements				Maximum Project Growth		15%
CON-1	10-Year Nonstructural	• Potential for construction modification and claims? • Special equipment or subcontractors needed?	If the current plan holds and individual homeowners are put in charge of their own floodproofing contracts, then there could be some issues with them hiring competent contractors, thus resulting in claims or mods. Also, there could be increased costs due to the number of similar contracts in a small area, causing contractors to raise prices due to rising demand. This could lead to a significant increase in cost.	Marginal	Possible	1
CE-2	Cultural Resources Mitigation	• Potential for construction modification and claims? • Special equipment or subcontractors needed?	Contractors specializing in historic preservation may be required with some procurement difficulty and increased costs.	Moderate	Possible	2
CE-3	0			Negligible	Unlikely	0
CE-4	0			Negligible	Unlikely	0

CE-5	0			Negligible	Unlikely	0
CE-6	0			Negligible	Unlikely	0
CE-7	0			Negligible	Unlikely	0
CE-8	0			Negligible	Unlikely	0
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	An accelerated schedule on the design stage would potentially cause modifications increasing the cost of engineering during construction.	Marginal	Likely	2
CE-14	Construction Management	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims?	If the current plan holds and individual homeowners are put in charge of their own floodproofing contracts, then there could be some issues with them hiring competent contractors, thus resulting in claims or mods. Also, there could be increased costs due to the number of similar contracts in a small area, causing contractors to raise prices due to rising demand. This could lead to a significant increase in cost.	Marginal	Possible	1
Specialty Construction or Fabrication					**Maximum Project Growth**	**50%**
SC-1	10-Year Nonstructural	• Confidence in contractor's ability to install?	If the current plan hold and individual homeowners are put in charge of their own floodproofing contracts, then there could be some issues with them hiring competent contractors.	Marginal	Possible	1
SC-2	Cultural Resources Mitigation	• Confidence in contractor's ability to install?	Contractors specializing in historic preservation may be required with some procurement difficulty and increased costs.	Marginal	Possible	1
SC-3	0			Negligible	Unlikely	0
SC-4	0			Negligible	Unlikely	0

SC-5	0			Negligible	Unlikely	0
SC-6	0			Negligible	Unlikely	0
SC-7	0			Negligible	Unlikely	0
SC-8	0			Negligible	Unlikely	0
SC-9	0			Negligible	Unlikely	0
SC-10	0			Negligible	Unlikely	0
SC-11	0			Negligible	Unlikely	0
SC-12	Remaining Construction Items			Negligible	Unlikely	0
SC-13	Planning, Engineering, & Design	• No concerns.	• No concerns.	Negligible	Unlikely	0
SC-14	Construction Management	• No concerns.	• No concerns.	Negligible	Unlikely	0
Technical Design & Quantities				**Maximum Project Growth**		**20%**
T-1	10-Year Nonstructural	• Level of confidence based on design and assumptions? • Appropriate methods applied to calculate quantities? • Sufficient investigations to develop quantities?	Based on the preliminary model, there are 224 structures that need to be treated. However, there is a possibility that with a more detailed analysis, there will be more structures that need to be added to the list. This could add singificant cost to the project.	Marginal	Likely	2
T-2	Cultural Resources Mitigation	• Level of confidence based on design and assumptions? • Appropriate methods applied to calculate quantities? • Sufficient investigations to develop quantities?	Based on the preliminary model, there are 224 structures that need to be treated. However, there is a possibility that with a more detailed analysis, there will be more structures that need to be added to the list. This could add singificant cost to the project. A change in quantities would impact the mitigation on cultural mitigations.	Marginal	Possible	1
T-3	0			Negligible	Unlikely	0
T-4	0			Negligible	Unlikely	0

T-5	0			Negligible	Unlikely	0
T-6	0			Negligible	Unlikely	0
T-7	0			Negligible	Unlikely	0
T-8	0			Negligible	Unlikely	0
T-9	0			Negligible	Unlikely	0
T-10	0			Negligible	Unlikely	0
T-11	0			Negligible	Unlikely	0
T-12	Remaining Construction Items			Negligible	Unlikely	0
T-13	Planning, Engineering, & Design	• Level of confidence based on design and assumptions?	As design evolves quantities on current project may change.	Negligible	Likely	1
T-14	Construction Management	• Level of confidence based on design and assumptions?	As design evolves quantities on current project may change.	Negligible	Likely	1
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
EST-1	10-Year Nonstructural	• Overuse of Cost Book, lump sum, allowances? • Reliability and number of key quotes? • Lack confidence on critical cost items?	The estimate is mostly based on costbook assumptions for the floodproofing, so there could be some areas where costs have been underestimated. However, the impacts due to this would be marginal, as the majority of items are priced in the ballpark.	Marginal	Likely	2
EST-2	Cultural Resources Mitigation	• Overuse of Cost Book, lump sum, allowances? • Reliability and number of key quotes? • Lack confidence on critical cost items?	The estimate is mostly based on costbook assumptions for the floodproofing, so there could be some areas where costs have been underestimated. However, the impacts due to this would be marginal, as the majority of items are priced in the ballpark.	Marginal	Likely	2
EST-3	0			Negligible	Unlikely	0

EST-4	0			Negligible	Unlikely	0
EST-5	0			Negligible	Unlikely	0
EST-6	0			Negligible	Unlikely	0
EST-7	0			Negligible	Unlikely	0
EST-8	0			Negligible	Unlikely	0
EST-9	0			Negligible	Unlikely	0
EST-10	0			Negligible	Unlikely	0
EST-11	0			Negligible	Unlikely	0
EST-12	Remaining Construction Items			Negligible	Unlikely	0
EST-13	Planning, Engineering, & Design	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion?	Estimate assumptions and resulting cost and risks could cause a revision to design and require further coordination.	Negligible	Likely	1
EST-14	Construction Management	• Assumptions regarding crew, productivity, overtime? • Site accessibility, transport delays, congestion?	Estimate assumptions would not impact the S&A efforts to any degree.	Negligible	Unlikely	0
External Project Risks				**Maximum Project Growth**		**20%**
EX-1	10-Year Nonstructural	• Political influences, lack of support, obstacles? • Potential for market volatility impacting competition, pricing?	Participation rate is assumed at 100%. However, homeowners have the option to deny treatments. There is a limited number of contractors available in this market.	Moderate	Likely	3
EX-2	Cultural Resources Mitigation	• Political influences, lack of support, obstacles? • Potential for market volatility impacting competition, pricing?	A mitigation plan has not yet been developed. The type and scale of mitigation will be influenced by coordination with NJSHPO and the local historical groups. Contractors specializing in historic preservation may be limited in number and availability may affect the cost and schedule.	Negligible	Likely	1
EX-3	0			Negligible	Unlikely	0
EX-4	0			Negligible	Unlikely	0

EX-5	0			Negligible	Unlikely	0
EX-6	0			Negligible	Unlikely	0
EX-7	0			Negligible	Unlikely	0
EX-8	0			Negligible	Unlikely	0
EX-9	0			Negligible	Unlikely	0
EX-10	0			Negligible	Unlikely	0
EX-11	0			Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	0
EX-13	Planning, Engineering, & Design	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	External risks such as political, funding sources, weather, and enivornmental windows could impact project costs over time. Changes to permitting and biological requirements could result in added coordination and design efforts.	Marginal	Possible	1
EX-14	Construction Management	• Potential for severe adverse weather? • Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	External risks such as political, funding sources, weather, and enivornmental windows could impact project costs over time. Assuming design is 100% complete upon award, the only impact may be added coordination of external requirements occurring during course of construction and potential design changes resulting in modifications.	Marginal	Possible	1

MII

Print Date Fri 9 September 2016
Eff. Date 1/20/2016

U.S. Army Corps of Engineers
Project : Rahway River Watershed Flood Risk Management Project - Alternative # 4A
Alternative 4A

Time 11:42:29
summary Page 1

Description	UOM	Quantity	ContractCost
summary			**40,576,343.18**
Alternative #4A	**EA**	**1.0000**	**40,576,343.18**
03 - RESERVOIR	**LS**	**1.0000**	**33,339,037.51**
06 - Fish and Wildlife Facilities	**LS**	**1.0000**	**4,268,669.22**
09 - CHANNELS AND CANALS	**LS**	**1.0000**	**1,718,636.44**
18 - Cultural Resource Preservation	**LS**	**1.0000**	**1,250,000.00**

Labor ID: NLS2015 EQ ID: EP14R08 Currency in US dollars TRACES MII Version 4.2

Print Date Mon 24 October 2016
Eff. Date 3/28/2016

U.S. Army Corps of Engineers
Project : Rahway Fluvial
10-Year Nonstructural

Time 16:16:26

summary Page 1

Description	UOM	Quantity	ContractCost
summary			**6,650,790.97**
10 Year- Non-Structural Plan	**EA**	**1.0000**	**6,650,790.97**
18 CULTURAL RESOURCE PRESERVATION	**EA**	**1.0000**	**1,200,000.00**
19 BUILDINGS, GROUNDS, AND UTILITIES	**EA**	**21.0000**	**5,450,790.97**

DQC Comments

Draft Appendix E

Real Estate Plan

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

RAHWAY RIVER BASIN, NEW JERSEY FLOOD RISK MANAGEMENT FEASIBILITY STUDY

NOVEMBER 2016 REAL ESTATE PLAN

Table of Contents

1. Preamble

Project Authorization: The study was authorized in a resolution of the Committee on Transportation and Infrastructure of the U.S. House of Representatives. The Rahway River Basin resolution was dated 24 March 1998.

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army review the report of the Chief of Engineers on the Rahway River, New Jersey, published as House Document 67, 89th Congress, and other pertinent reports to determine whether any modifications of the recommendations contained therein are advisable at the present time, in the interest of water resources development, including flood control, environmental restoration and protection and other related purposes."*

Official Project Designation**:** Rahway River Basin, New Jersey, Flood Risk Management Feasibility Study (hereinafter the "Study," or "Project")

Project Location: An Initial Screening Report (2006) documented and recommended further investigation in the Township of Cranford and the City of Rahway along the Robinson's Branch, two areas within the basin that experienced regular flooding for past storm events. Due to this initial screening and through coordination with the non-Federal sponsor and local stakeholders, the main focus of the ongoing study has been on fluvial flooding within Cranford and Rahway The Rahway River Basin project area lies in portions of Essex, Middlesex and Union Counties in NJ. The project area lies in sections of the Townships of Cranford and West Orange and the City of Rahway. The project area is within the study area and is the area in which the flood risk management project would be constructed. The Rahway River flows through the municipalities of Springfield, Union, Cranford and Clark before traveling through the City of Rahway, entering from Clark at Rahway River Park. The Rahway River receives waters of Robinson's Branch at Elizabeth Avenue between West Grand Avenue and West Main Street and the waters of the South Branch at East Hazelwood Avenue and Leesville Avenue before it leaves the City of Rahway and enters the city limits of Linden and Carteret. The Rahway River then flows into the Arthur Kill. .

Non-Federal Sponsor: The non-Federal sponsor for this Project is the New Jersey Department of Environmental Protection (hereinafter referred to as "NJDEP" and/or the "Project Partner"). Based on the recommendation and approval of the Reconnaissance Report, a Feasibility Cost Sharing Agreement (FCSA) was executed in March 2002 with the NJDEP, with the cost of the study being **50% Federal** and **50% non-Federal.**

2. Statement of Purpose

This Real Estate Plan (the "REP") is prepared in support of the Rahway River Basin, New Jersey, Flood Risk Management Feasibility Study.

3. Project Purpose and Features

a. Project Purpose:

The purpose of the Project is to evaluate potential flood risk management solutions to frequent fluvial flooding problems within the Rahway River Basin, New Jersey.

b. Plan of Improvement:

This report will describe the Tentatively Selected Plan (TSP) for the Project that would meet this objective. This plan is not yet optimized and this REP may require further revisions upon optimization. The TSP is made up of a combination of two alternatives and is described as follows:

1) Cranford Alternative 4a. Alternative 4a consisting of channel modification in the Township of Cranford and a new outlet for the Orange Reservoir would provide flood risk management for the Township of Cranford. The modification of the Orange Reservoir also provides flood risk management for the upstream municipalities of Millburn and Springfield. . Required Lands, Easements and Rights of Way (LER) for this alternative will be summarized in section 4 below.

2) Robinson's Branch Non-Structural. The nonstructural flood risk management would consist of elevating all buildings within the 20% floodplain, as determined by ground elevation and all structures with a main floor elevation at or below +9.4 feet North American Vertical Datum of 1988 ("NAVD88"). The construction of the Project will be implemented on a voluntary basis in a single-construction phase. The Project Partner will be responsible for implementing the Project. Nonstructural floodproofing measures will be offered to owners of eligible structures on a voluntary basis. Eligible structures will, in addition, have to meet the following criteria:

- Owner is willing to participate in the nonstructural program and execute a Floodproofing Agreement containing a restrictive covenant limiting development of the property below the determined elevation.
- Structure is in a safe, decent and sanitary condition
- Owner possesses clear title to the property
- Structure and appurtenant land is not contaminated with hazardous, toxic or radioactive waste or materials
- Owner does not owe taxes or other debts to any state or local government entity or to the Federal Government

- Owner has not previously received any disaster assistance for the elevation of the structure
- Property owner is willing to expend costs that may be necessary in connection with the elevation of the structure which are not eligible costs covered by the program (i.e. temporary housing during construction)

Structures categorized within the voluntary program will be elevated or flood proofed only with the owner's consent. Where owners are willing to participate, but structures do not meet the program criteria, if cure is possible, owners will be afforded the opportunity to cure any defect in the structure, otherwise applications for ineligible structures will be denied.

Eminent domain authority will not be used to require landowners in this category to participate in the program; however, tenants who reside in structures to be elevated may be eligible for certain benefits in the accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970. See 49 C.F.R. 24.101(a)(2) for additional detail.

Where owners of eligible properties elect to participate in the Project, the following process shall be implemented:

- Property owner deliver a completed application for structure elevation to the Project Partner. The application must be signed by all owners and lien-holders of the property and structure;
- Project Partner shall ensure property meets all eligibility criteria;
- Property owner shall submit to Project Partner proof of ownership and a current Elevation Certificate;
- Project Partner shall conduct a title search to verify clear title;
- Project Partner shall conduct a Phase I HTRW/asbestos investigation. All asbestos must be abated and disposed of properly.
- Floodproofing Agreement is executed by property owner and Project Partner and recorded with the County clerk.
- Elevation of structure is completed.

c. <u>Required Lands, Easements, and Rights-of-Way (LER):</u>

<u>Cranford Alternative 4a</u>:

The parcel data is provided in Exhibit "B". The TSP, as described above in Section 3, requires a total of **2.52** acres in permanent easements and **4.56** acres in temporary work area easements, totaling **7.08 acres**. This alternative impacts a total of **113 parcels**. This plan is not yet optimized and further revisions to the parcel data may need to be done after optimization; at which point this REP may need to be revised accordingly.

Easements for this alternative will include a combination of the following Standard Estates, a full description of the standard estates are provided in Exhibit "C". **Channel Improvement**

Easements (Standard Estate No. 8) will be used where any channel improvement work will take place. **Flood Protection Levee Easements (Standard Estate No. 9)** will be used where levees, gate structures and/or pumping station work is going to take place. **Temporary Work Area Easements (Standard Estate No. 15)** will be used where temporary access is needed to support construction and/or staging areas.

<u>Robinson's Branch Non-structural Alternative</u>:

Parcel data for this alternative has not been provided in this REP, however, it is estimated this alternative will impact a total of **twenty-one** (**21)** parcels that occupy approximately **4.84** acres of land; they will be identified upon optimization of the Project. Currently, the New York District is awaiting nonstructural flood-proofing implementation guidance from USACE Headquarters. The forthcoming guidance may alter the real estate instruments used to enable construction of this alternative. Pending receipt of further guidance, New York District offers the following tentative schedule of required LER for this alternative. Upon further guidance and optimization, New York District may need to revise this REP accordingly.

The estates required for this alternative are individual Rights of Entry for Survey and Exploration ("ROE") and corresponding Floodproofing Agreements, a full description of these estates are provided in Exhibit "C". ROEs will be required on the entire lot of the 21 properties that will be identified upon optimization of the Project. The ROEs will serve to allow the Project Partner to enter into the property and investigate to ensure the property meets the eligibility criteria identified in section 3(b) above. This includes verifying that the structure is in decent, safe and sanitary condition, and a Phase 1 HTRW investigation. In addition to Rights of Entry, the Project requires Floodproofing Agreements executed between property owner and Project Partner. The Floodproofing Agreement will provide the mechanism for the floodproofing work to occur, as well as a restrictive covenant limiting development on the property below a determined elevation.

d. <u>Appraisal Information:</u>

A Land Cost Estimate Appraisal was prepared on May 26, 2016 identifying the real estate acquisition costs for the required LER of the Cranford Alternative 4a at a value of **$525,000**, including a 20% contingency. The Robinson's Branch Non-Structural Alternative, contemplates acquisition of up to twenty-one Rights of Entry for Survey and Exploration, and up to twenty-one Floodproofing Agremeents. As the Non-Structural treatments are voluntary in nature, the ROEs and Floodproofing Agreements have no market value and no appraisal is required.

4. <u>LER Owned by the Non-Federal Partner:</u>

The non-Federal Sponsor does not own any of the LER required for the Project.

5. <u>Non-Standard Estates</u>

The Project does not require the use of any non-standard estates.

6. Existing Federal Projects

There are no existing Federal projects that lie either fully or partially within the LER required for the Project. However, there are existing Federal projects near the project area in the South Branch and Rahway Tidal Study.

7. Federally-Owned Land

No Federally-owned land is included within the Project's required LER.

8. Navigational Servitude

None of the LER required for the Project lies below the mean high water line. Therefore, rights in the Federal navigational servitude do not pertain to this Project.

9. Maps

The overall Project map is provided in Exhibit "A" herein. When the final plan is optimized a more detailed Real Estate map will be prepared and this Real Estate Plan will be revised.

10. Induced Flooding

The Project will not induce flooding.

11. Baseline Cost Estimate for Real Estate

An itemized BCERE is provided in Exhibit "D" in Micro-Computer Aided Cost Estimating System (MCACES) format with estimated real estate costs. The following is a summary of the Project's estimated real estate costs:

SUMMARY OF ESTIMATED REAL ESTATE COSTS FOR CRANFORD BRANCH ALTERNATIVE 4A:

01 ACCOUNT LANDS AND DAMAGES (NON FED)	Cost	Total
Non-Federal Admin. --	$1,294,500	
Non-Federal Lands---	$525,000	
Subtotal:		**$1,819,500**
20% Contingency	$258,900	
01 ACCOUNT TOTAL		**$2,078,400**
30 ACCOUNT – PROJECT MANAGEMENT COSTS (FED)		
Federal Admin --	$534,598	
Subtotal:		**$534,598**
20% Contingency	$106,920	

30 ACCOUNT TOTAL		**$641,518**
TOTAL ESTIMATED REAL ESTATE PROJECT COST		**$2,719,918**

SUMMARY OF ESTIMATED REAL ESTATE COSTS FOR ROBINSON'S BRANCH NON-STRUCTURAL ALTERNATIVE:

01 ACCOUNT LANDS AND DAMAGES (NON FED)	Cost	Total
Non-Federal Admin. --	$292,700	
Non-Federal Lands---	$0	
Subtotal:		**$292,700**
20% Contingency	$58,540	
01 ACCOUNT TOTAL		**$351,240**
30 ACCOUNT – PROJECT MANAGEMENT COSTS (FED)		
Federal Admin --	$111,866	
Subtotal:		**$111,866**
20% Contingency	$22,373	
30 ACCOUNT TOTAL		**$134,239**
TOTAL ESTIMATED REAL ESTATE PROJECT COST		**$485,479**

12. Public Law 91-646, Uniform Relocation Assistance

Property owners and occupants of eligible residential structures who willingly participate in the residential elevation program are not considered displaced persons (in accordance with 49 CFR Part 24), and therefore are not entitled to receive relocations assistance benefits. However, displaced tenants of eligible residential structures to be elevated, are eligible for temporary relocations assistance benefits. Eligible tenants that temporarily relocate would be reimbursed for the cost of temporary alternate housing, meals and incidentals (such as laundry services), and the fees for disconnection and connection of utilities at the temporary residence. Alternate housing could be hotels or apartments, depending upon availability in the community. All temporary housing costs would need to be approved in advance by the Non Federal Sponsor. Hotel costs, and meals and incidental expenses would be reimbursed based on the applicable General Services Administration per diem rates. Apartment costs would be based on market rents.

Estimated temporary relocation costs for tenants is based on the following assumptions:

- The U.S. Census Bureau estimates the home ownership rate in the City of Rahway at approximately 42%. Based on this assumption, approximately eight of the twenty-one homes may be occupied by tenants that may qualify for temporary relocation assistance benefits. This is an assumption for planning purposes only and the Non-Federal Sponsor will have to confirm the number of displaced tenants before the acquisition phase.

The estimated temporary relocation benefits combined with the estimated moving expense payment yields an estimated temporary relocation cost of approximately $13,375 per displaced tenant household. Based on these assumptions, the total estimated relocation assistance benefits paid in support of the Project are approximately **$107,000**.

13. Minerals and Timber Activity

There are no present or anticipated mineral activities or timber harvesting within the LER required for the Project.

14. Land Acquisition Experience and Capability of the Non-Federal Project Partner

The Project Partner maintains the legal and professional capability and experience to acquire the LER in support of the Project. They have condemnation authority and other applicable authorities that may apply if necessary to support acquisition measures.

The Non-Federal Project Partner Capability Assessment Checklist is provided in Exhibit "E". The assessment checklist has been coordinated with the Project Partner: however, the Project Partner has provided no response to the assessment. It has been completed based on the Project Partner's past and current performance on other USACE cost-shared civil works projects.

15. Zoning

No application or enactment of local zoning ordinances is anticipated in lieu of, or to facilitate, the acquisition of LER in connection with the Project.

16. Schedule of Acquisition

Milestone	Date
Project Partnership Agreement Execution-------------------------------------	September 2017
Project Partner's Notice to Proceed with Acquisition-------------------------	March 2019
Authorization for Entry for Construction--------------------------------------	September 2019
Certification of Real Estate---	September 2019
Ready to Advertise for Construction---	October 2019

17. Facility / Utility Relocations

The Project will not require the relocation of any facilities or utilities.

18. Hazardous, Toxic, and Radioactive Waste (HTRW)

There are no known contaminants or HTRW issues associates with the LER required for the Project; however, the Project Partner will conduct Phase 1 environmental assessments all potential structures to verify the absence of asbestos, lead paint, or other such contaminants posing a health hazard. Presence of such contaminants will render a structure ineligible for flood proofing.

19. Project Support

Local officials and residents appear to be supportive of the Project. No opposition has been expressed by public or private persons or organizations on the implementation of the proposed Project. Implementation of the nonstructural flood proofing contemplated by the Project will be conducted on a voluntary basis and support from affected property owners is critical to the Project's success.

20. Notification to Non-Federal Project Partner

A formal written notification of the risks (as outlined in paragraph 12-31, Chapter 12, ER 405-1-12, Real Estate Handbook, 20 Nov 85) associated with acquiring the LER for this project prior to the full execution of the PPA through letter dated January 14, 2014.

21. Other Issues

Real estate analysis on the Project's potential impact to historic properties have not been completed at the time this report was written, Real Estate analysis on any impacts will take place during plan optimization and this report may need to be revised based on those findings.

22. Point of Contacts

The points of contact for this real estate plan is the Real Estate Project Delivery Team member Supervisory Realty Specialist Erica A. Labeste at (917) 790 8461 (email: Erica.A.Labeste@usace.army.mil) or the Chief, Real Estate Division, Noreen D. Dresser at (917)790-8430 (email: Noreen.D.Dresser@usace.army.mil).

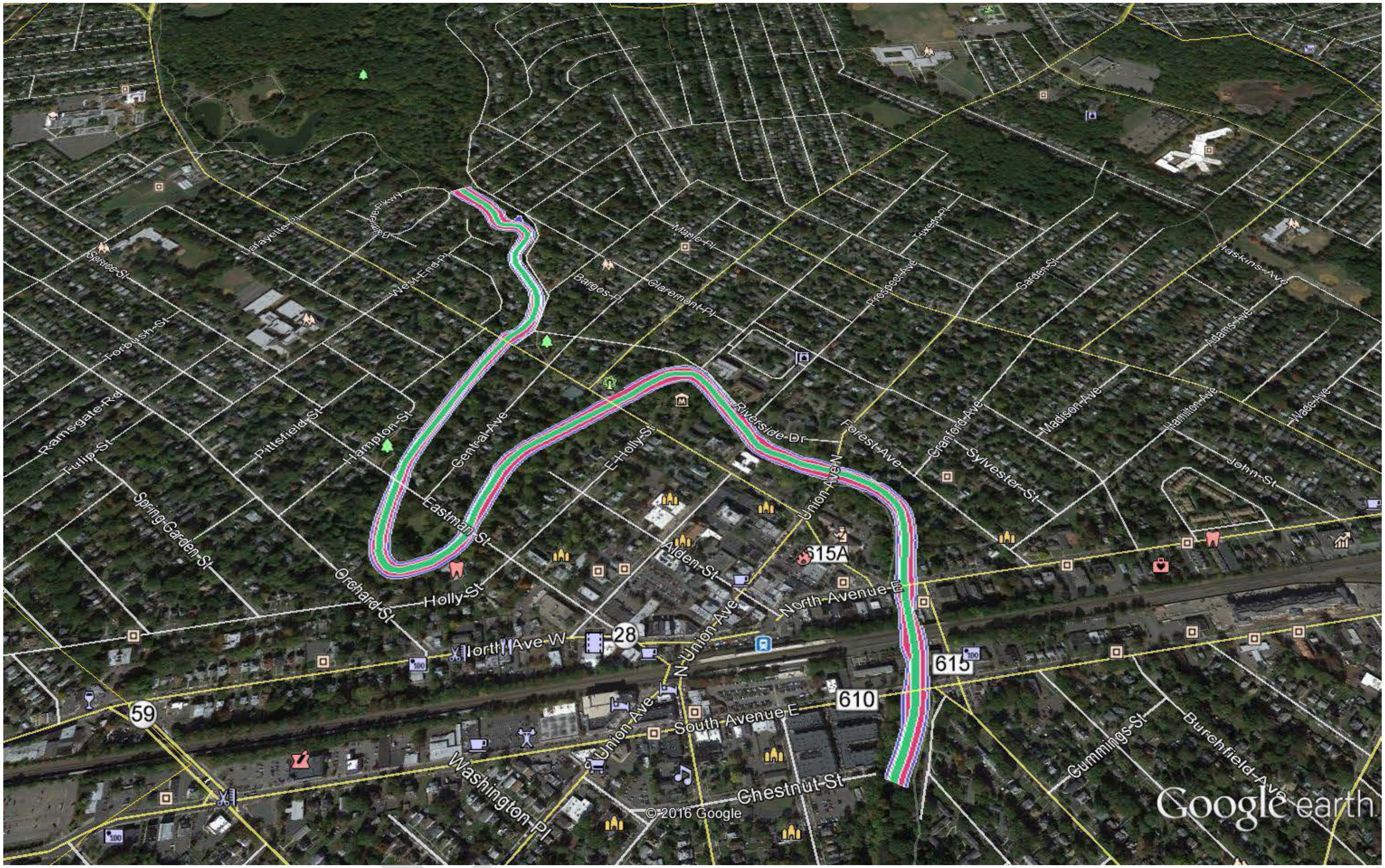
23. Recommendations

This Real Estate Plan has been prepared in accordance with Chapter 12, ER 405-1-12, Real Estate Handbook, 20 NOV 85, as amended. It is recommended that this report be approved.

ERICA A. LABESTE
Supervisory, Realty Specialist
Real Estate Division

EXHIBIT “A”

OVERALL PROJECT MAP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Forest Ave
Union Ave N
Cranford Ave
Sylvester St
Madison Ave
Hamilton Ave
John St
Central Ave
E Holly St
Eastman St
Alden St
Holly St
Orchard St
Spring Garden St
Tulip St
Ramsgate Rd
Pittsfield St
Hampton St
West End Pl
Bargos Pl
Claremont Pl
Maple Pl
Prospect Ave
Garden St
Haskins Ave
Adams Ave
North Avenue E
North Ave W
N Union Ave
South Avenue E
Union Ave
Washington Pl
Chestnut St
Cummings St
Burchfield Ave
28
59
610
615
615A
©2016 Google
Google earth

EXHIBIT “B”

REQUIRED LER

RAHWAY RIVER BASIN, NEW JERSEY FLOOD RISK MANAGEMENT FEASIBILITY STUDY
REQUIRED LER

Temporary Work Area Easements

PAMS_PIN	MUN	BLOCK	LOT	Shape_Area
2003_261_4	2003	261	4	1039.723483
2003_184_10	2003	184	10	404.057144
2003_262_3.01	2003	262	3.01	4008.95335
2003_263_1	2003	263	1	4230.327518
2003_312_17	2003	312	17	2355.515664
2003_312_9	2003	312	9	728.286319
2003_312_7	2003	312	7	1538.324779
2003_261_8	2003	261	8	859.029354
2003_262_9	2003	262	9	3664.843922
2003_262_8	2003	262	8	1482.635969
2003_200_46	2003	200	46	2121.293869
2003_200_45	2003	200	45	1695.066359
2003_200_44	2003	200	44	1344.615481
2003_200_43	2003	200	43	1606.676597
2003_800_3	2003	800	3	4032.732075
2003_507_1	2003	507	1	1490.964809
2003_261_5	2003	261	5	1068.033719
2003_261_3	2003	261	3	854.259789
2003_261_2	2003	261	2	569.680147
2003_169_9	2003	169	9	1506.149242
2003_169_8	2003	169	8	1145.914818
2003_169_7	2003	169	7	1125.699069
2003_169_6	2003	169	6	1415.450263
2003_169_5	2003	169	5	1512.072066

Permanent Easements

PAMS_PIN	MUN	BLOCK	LOT	Shape_Area
2003_261_4	2003	261	4	890.564284
2003_262_3.01	2003	262	3.01	6304.174955
2003_263_1	2003	263	1	11.143544
2003_312_18	2003	312	18	2897.053916
2003_312_17	2003	312	17	852.061957
2003_312_9	2003	312	9	1147.170839
2003_312_7	2003	312	7	1652.751129
2003_262_9	2003	262	9	5578.855207
2003_262_8	2003	262	8	150.997939
2003_200_46	2003	200	46	359.370907
2003_200_45	2003	200	45	1171.933721
2003_200_44	2003	200	44	230.148939
2003_200_43	2003	200	43	75.799382
2003_507_1	2003	507	1	2485.195459
2003_261_5	2003	261	5	514.921924
2003_261_3	2003	261	3	541.174203
2003_261_2	2003	261	2	81.526887
2003_261_1	2003	261	1	15.341836
2003_169_9	2003	169	9	791.260449
2003_169_8	2003	169	8	98.528388
2003_169_6	2003	169	6	65.386686
2003_169_5	2003	169	5	873.397171
2003_169_4	2003	169	4	579.099916
2003_169_3	2003	169	3	495.69731

2003_169_4	2003	169	4	1363.918759
2003_169_3	2003	169	3	1676.421457
2003_169_2	2003	169	2	1336.642032
2003_169_1	2003	169	1	1338.599686
2003_180_1	2003	180	1	13022.0585
2003_179_17	2003	179	17	1169.544694
2003_179_16	2003	179	16	996.960656
2003_179_15	2003	179	15	1750.791482
2003_179_4	2003	179	4	773.57299
2003_179_3	2003	179	3	1281.012891
2003_179_2	2003	179	2	928.308508
2003_179_1	2003	179	1	405.244786
2003_179_12	2003	179	12	740.632929
2003_179_11	2003	179	11	842.31955
2003_179_10	2003	179	10	944.458571
2003_262_7	2003	262	7	1707.287378
2003_185_6	2003	185	6	1045.465752
2003_185_5	2003	185	5	1068.408894
2003_185_4	2003	185	4	1076.935114
2003_185_3	2003	185	3	1066.040911
2003_185_2	2003	185	2	1068.584961
2003_185_1	2003	185	1	1018.149821
2003_184_11	2003	184	11	413.621559
2003_184_1	2003	184	1	2171.541831
2003_261_7	2003	261	7	1152.476937
2003_195_11	2003	195	11	2446.974662
2003_184_5	2003	184	5	1128.083048
2003_184_4	2003	184	4	451.919281
2003_482_1	2003	482	1	4744.457028
2003_200_38	2003	200	38	209.43074

2003_169_2	2003	169	2	336.680938
2003_169_1	2003	169	1	274.169715
2003_180_1	2003	180	1	10160.01706
2003_179_17	2003	179	17	523.71381
2003_179_16	2003	179	16	25.041755
2003_179_15	2003	179	15	119.930635
2003_179_3	2003	179	3	62.97109
2003_179_12	2003	179	12	11.857929
2003_179_11	2003	179	11	28.112296
2003_179_10	2003	179	10	211.976484
2003_262_7	2003	262	7	3772.502017
2003_185_6	2003	185	6	704.23885
2003_185_5	2003	185	5	778.737828
2003_185_4	2003	185	4	1058.73602
2003_185_3	2003	185	3	1085.887304
2003_185_2	2003	185	2	1265.323941
2003_185_1	2003	185	1	418.442044
2003_184_1	2003	184	1	874.163795
2003_261_7	2003	261	7	26.314645
2003_195_11	2003	195	11	479.884335
2003_184_5	2003	184	5	270.027096
2003_482_1	2003	482	1	5621.430703
2003_179_14	2003	179	14	129.830967
2003_179_13	2003	179	13	240.752642
2003_262_6	2003	262	6	4391.135656
2003_196_2.01	2003	196	2.01	9622.557661
2003_200_33	2003	200	33	2048.00001
2003_200_32	2003	200	32	1579.066094
2003_105_1	2003	105	1	299.182748
2003_103_1	2003	103	1	4836.304119

2003_179_14	2003	179	14	439.890485
2003_179_13	2003	179	13	752.949267
2003_262_6	2003	262	6	3276.613519
2003_262_7_C02B	2003	262	7	81.827208
2003_196_2.01	2003	196	2.01	11051.46124
2003_200_33	2003	200	33	1763.373726
2003_200_32	2003	200	32	1670.641625
2003_179_9	2003	179	9	573.39441
2003_179_8	2003	179	8	117.667867
2003_179_7	2003	179	7	547.309122
2003_105_1	2003	105	1	1920.4816
2003_103_1	2003	103	1	17651.60471
2003_200_48	2003	200	48	979.762285
2003_200_47	2003	200	47	2206.352951
2003_200_34	2003	200	34	1.073287
2003_262_7_C05G	2003	262	7	81.236614
2003_262_5	2003	262	5	2434.340416
2003_481_1.01	2003	481	1.01	4695.115411
2003_480_2	2003	480	2	1840.747409
2003_480_1	2003	480	1	816.611108
2003_479_5	2003	479	5	2691.784578
2003_168_9	2003	168	9	2172.804
2003_168_8	2003	168	8	1106.190316
2003_168_7	2003	168	7	1118.183961
2003_168_6	2003	168	6	458.288226
2003_168_5	2003	168	5	1398.176048
2003_168_4	2003	168	4	2013.814116
2003_168_3	2003	168	3	1617.14578
2003_168_2	2003	168	2	1174.086104

2003_200_48	2003	200	48	36.665035
2003_200_47	2003	200	47	1289.267048
2003_262_5	2003	262	5	2843.855221
2003_481_1.01	2003	481	1.01	2061.20838
2003_480_2	2003	480	2	620.118121
2003_480_1	2003	480	1	298.311605
2003_479_5	2003	479	5	683.183588
2003_168_9	2003	168	9	652.695697
2003_168_8	2003	168	8	848.758181
2003_168_7	2003	168	7	811.895084
2003_168_6	2003	168	6	281.203266
2003_168_5	2003	168	5	562.607909
2003_168_4	2003	168	4	1306.72478
2003_168_3	2003	168	3	1178.172073
2003_168_2	2003	168	2	383.132361
2003_168_1	2003	168	1	648.292548
2003_169_12	2003	169	12	1913.19909
2003_169_10	2003	169	10	951.518278
2003_200_37	2003	200	37	1104.877381
2003_200_36	2003	200	36	1044.712986
2003_200_35	2003	200	35	17.973724
2003_185_7	2003	185	7	976.92055
2003_184_9	2003	184	9	130.953475
2003_184_8	2003	184	8	286.139768
2003_184_7	2003	184	7	665.697997
2003_184_6	2003	184	6	481.399971
2003_186_7	2003	186	7	4.179321
2003_186_2	2003	186	2	227.075267
2003_186_1	2003	186	1	872.49257

2003_168_1	2003	168	1	4034.053073
2003_169_12	2003	169	12	2096.261392
2003_169_10	2003	169	10	1506.445783
2003_200_1	2003	200	1	57.469337
2003_200_37	2003	200	37	2349.272741
2003_200_36	2003	200	36	1769.706361
2003_200_35	2003	200	35	816.842794
2003_185_7	2003	185	7	1030.278407
2003_184_9	2003	184	9	663.290184
2003_184_8	2003	184	8	679.281905
2003_184_7	2003	184	7	715.650213
2003_184_6	2003	184	6	741.649787
2003_186_7	2003	186	7	585.768846
2003_186_6	2003	186	6	69.14745
2003_186_3	2003	186	3	159.403731
2003_186_2	2003	186	2	1324.602215
2003_186_1	2003	186	1	1623.4344
2003_184_18	2003	184	18	2148.484713
2003_184_14	2003	184	14	1621.259543
2003_184_13	2003	184	13	1605.048317
2003_184_12	2003	184	12	1426.155055
2003_312_6	2003	312	6	1590.521717
2003_312_5	2003	312	5	1418.75738
2003_312_4	2003	312	4	924.673586
2003_312_3	2003	312	3	1213.566287
2003_312_2	2003	312	2	1525.404371
2003_312_1	2003	312	1	760.380392
2003_313_1	2003	313	1	1427.046698
2003_262_1	2003	262	1	4774.444836

2003_184_18	2003	184	18	757.426139	
2003_184_14	2003	184	14	840.814867	
2003_184_13	2003	184	13	278.27319	
2003_184_12	2003	184	12	3.212319	
2003_312_6	2003	312	6	982.150202	
2003_312_5	2003	312	5	926.395452	
2003_312_4	2003	312	4	144.120652	
2003_312_2	2003	312	2	9.538895	
2003_313_1	2003	313	1	1788.506478	
2003_262_1	2003	262	1	1573.003991	
				109607.2206	square ft.
				2.516235551	acre

2003_262_7_C02C	2003	262	7	81.236539	
2003_262_7_C05F	2003	262	7	81.236997	
				198613.8736	square ft.
				4.559547145	acre

EXHIBIT "C"

STANDARD ESTATES

Channel Improvement Easement (Standard Estate No. 8)

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across *[Section, Block, and Lot]* for the purposes as authorized by the Act of Congress approved in Section 401(a) of the Water Resources Development Act of 1986 (Public Law 99-662), including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

Flood Protection Levee Easement (Standard Estate No. 9)

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection (levee) (floodwall)(gate closure) (sandbag closure), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easement (Standard Estate No. 15)

A temporary easement and right-of-way in, on, over and across *[Section, Block, and Lot]* for a period not to exceed three (3) years, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Rahway River Basin Flood Risk Management Project**,** together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Right of Entry for Survey and Exploration (Standard Estate No. 20)

An assignable easement, in, on, over and across the land described in Exhibit "A" for a period of (   ) months beginning with the date possession of the land is granted to the United States, consisting of the right of the United States, its representative, agents, contractors and assigns to enter upon said land to survey, stake out, appraise, make borings; and conduct tests and other exploratory work necessary to the design of a public works project; together with the right to trim, cut, fell, and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles as required in connection with said work; subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowner(s), their heirs, executors, administrators, successors and assigns, all such right, title, interest and privilege as may be used and enjoyed without interfering with or abridging the rights and easement hereby acquired.

Non-structural Floodproofing Agreement

TRACT NO. [TRACT]

RAHWAY FLUVIAL NONSTRUCTURAL FLOOD CONTROL PROJECT

WHEREAS, pursuant to Public Law 96-367 (Title II, Section 202, of the Energy and Water Development Appropriation Act, 1981), as amended, and pursuant to the provisions of the Project Partnership Agreement (hereinafter referred to as the "PPA") dated [DATE] between the United States of America (hereinafter sometimes referred to as the "Government") and the New Jersey Department of Environmental Project (hereinafter sometimes referred to as the "NJDEP"), NJDEP has undertaken the implementation of the Rahway Fluvial Nonstructural Flood Control Project (hereinafter sometimes referred to as the "Project");

WHEREAS, implementation of the Project includes, inter alia, the floodproofing of certain structures so that the habitable floors thereof are raised to levels or protected by other means in such a manner which will protect the structures from certain flooding to the greater extent practicable by allowing the free movement of floodwater beneath and around the structures;

WHEREAS, pursuant to the PPA, the has undertaken floodproofing and acquisitions of interests in land for and on behalf of the County;

WHEREAS, [PROPERTY OWNER]; (hereinafter sometimes referred to as the "Owner"), is the Owners of a certain parcel of land identified by the NJDEP as Tract No. [TRACT], and being the same land as that described in a deed from [ACQURIING TRANSACTION DESCRIPTION], which existing structure can and shall be floodproofed in compliance with this agreement and;

WHEREAS, it is the desire of the Owner to participate in and receive the benefits of the Project;

NOW, THEREFORE, THIS AGREEMENT AND GRANT made and entered into by and between [OWNER]; and the NJDEP, as aforesaid;

WITNESSETH, that for and in consideration of the premises and the mutual agreements and covenants hereinafter set forth;

1. The NJDEP, in conjunction with the Government, hereby agrees floodproof the subject structure through elevation of the structure. The Owner shall permit entry upon the property by an authorized Government contractor, and permit said contractor to modify the structure consistent with contractor design to be developed. The Owner shall further permit an inspection or inspections of the floodproofing work by the NJDEP, its contractors, assigns or representatives upon completion of the work, and/or at any time during the work's progress, to ensure that the work is acceptable to the NJDEP and has been satisfactorily performed to meet the Project's criteria as to design, construction, and protection. Provided, further, that the floodproofed structure shall

not be located within the regulatory floodway. Provided, further, that, should the Owner incur any cost in excess of said amount, that cost shall be borne by the Owner unless such additional amount is expressly approved in writing by the Government as necessary for the purposes of flood damage reduction.

3. The Owner hereby agrees that the Owner shall not convey to any third party any interest in and to said land and the structures or create any liens thereon prior to completion of said floodproofing work and recordation of this Agreement by the Government in the land records of Union County, New Jersey, without the prior written approval of the Government.

4. The Owner hereby acknowledges that the Government has made no warranties or guarantees whatsoever in connection with the Contractor or with the Contractor's ability to satisfactorily perform the work; and, that, as between the Government and the Owner, the Owner is solely responsible to arrange for the Contractor's satisfactory completion of the work in accordance herewith.

5. Further, that for and in the consideration aforesaid, the receipt and sufficiency of which are hereby acknowledged, the Owner, for herself and her heirs and assigns, do hereby GRANT, unto the NJDEP, and its assigns, the perpetual right, power, and privilege of access to said land and any structures thereon at all reasonable times considered necessary by the NJDEP, its contractors, assigns or representatives to ensure that this Agreement, its covenants and restrictions, and the intents and purposes of the project are being complied with by the Owner, for herself and her heirs and assigns.

6. The Owner, for herself and her heirs and assigns, hereby covenant and warrant to the NJDEP, and to its assigns forever, and agree, that no construction, alteration, or placement of structures of any kind or nature whatsoever on said land shall take place unless the lowest floor thereof to be used for human habitation, commercial or business purposes is elevated above [DETERMINED ELEVATION] feet mean sea level, and this restriction also prohibits the placement of water damageable material of any kind below the stated elevation of [DETERMINED ELEVATION] mean sea level, and any use of materials below this elevation must meet the requirement of "Flood Resistant Material" as defined in the Federal Emergency Management Agency's (FEMA) FIA-TB-2(4/93)(Technical Bulletin 2-93) this restriction and requirement shall be specifically included in every instrument subsequent hereto conveying title to any interest in said land or structures thereon.

7. The Owner, for herself and her heirs and assigns, hereby covenant, warrant, and agree she will forever hold and save harmless and blameless the Government and the NJDEP, and its assigns, from any damages or injuries resulting either directly or indirectly from any floodproofing work and any flooding of said land or of the floodproofed structure.

8. The Owner, for herself and her heirs and assigns, recognize and agree that the grant hereby made to the NJDEP, and the covenants and restrictions herein, in connection with the Leonardo Nonstructural Flood Control Project, are necessary and appropriate to ensure the purposes of said Project, namely, as authorized by Section 202 of the Water Resources and Development Act of 1981, Public Law 96-367, as amended, to afford a level of protection against flooding at least

sufficient to prevent any future losses from the likelihood of flooding as [LEVEL OF PROTECTION], whichever is greater; and, that for those purposes the NJDEP, and its assigns, shall forever have the right unchallenged by the Owner, and by the Owner's heirs and assigns, to seek legal enforcement of all of the provisions contained herein, it being the intentions of the parties that said provisions shall attach to and run with the land forever.

9. It is further provided that the obligations of the Government herein are contingent upon the Owner obtaining, as may be acceptable to the Government, the consent of any lienholder or tenants to the terms of this Agreement and obtaining from any lienholder or tenants waivers, releases, and/or subordinations of her rights in the premises to the extent necessary to accomplish the work and covenants and restrictions herein, as may be required by the Government.

IN WITNESS WHEREOF, the parties have executed this Agreement and Deed effective as of the date of acceptance hereof by the New Jersey Department of Environmental Protection.

____
[OWNER NAME] Owner

____
[OWNER NAME], Owner

ACKNOWLEDGEMENT

STATE OF ______________

COUNTY OF ______________

The foregoing instrument was acknowledged before me this ____ day of ______________, 2015, by [OWNER NAME] and [OWNER NAME].

____
NOTARY PUBLIC

My Commission Expires:

____

ACCEPTED:

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROJECTION

By: ______________________________ [TITLE]

______________ DATE

ACKNOWLEDGEMENT

STATE OF NEW JERSEY

COUNTY OF UNION

On this _____ day of ___________________, [YEAR], the undersigned officer, personally appeared ____________________________, [TITLE], New Jersey Department of Environmental Protection, known to me to be the person described in the foregoing Agreement and Deed, and acknowledged that he executed the same in the capacity therein stated and for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

(Seal) ______________________________

NOTARY PUBLIC

My Commission Expires:

____

THIS INSTRUMENT WAS PREPARED BY:

____

[NAME], Attorney
[ADDRESS 1]
[ADDRESS 2]

EXHIBIT “D”

BASELINE COST ESTIMATE FOR REAL ESTATE

TOTAL PROJECT REAL ESTATE COSTS (Cost-Shared 50%-50%)		Non-Federal	Federal	Project Cost
	CRANFORD BRANCH (ALTERNATIVE 4A)			
	Cost Summary:			
	Incidental Costs (01A)	$1,294,500	$534,598	$1,829,098
	Real Estate Acquisition Costs (01B)	$525,000	$0	$525,000
	Subtotal:	$1,819,500	$534,598	$2,354,098
	20% Contingency, Less Land Payments (01B1)	$258,900	$106,920	$365,820
01	**LANDS AND DAMAGES**	$2,078,400	$641,518	**$2,719,918**
01A	**INCIDENTAL COSTS**	**$1,294,500**	**$534,598**	**$1,829,098**
01A1	**Acquisition (Admin Costs)**	**$150,000**	**$75,000**	
01A1 A	By Government (Gov't)		$75,000	
01A1 B	By Non-Federal Sponsor (NFS)	$150,000		
01A1 C	By Gov't on behalf of NFS			
01A2	**Survey**	**$56,500**	**$28,250**	
01A2 A	By Gov't (In-house)			
01A2 B	By Gov't (Contract)			
01A2 C	By NFS	$56,500		
01A2 D	By Gov't on behalf of NFS			
01A2 E	Review of NFS		$28,250	
01A3	**Appraisal**	**$452,000**	**$158,200**	
01A3 A	By Gov't (In-house)			
01A3 B	By Gov't (Contract)			
01A3 C	By NFS	$452,000		
01A3 D	By Gov't on behalf of NFS			
01A3 E	Review of NFS		$158,200	
01A4	**Title Services**	**$565,000**	**$56,500**	
01A4 A	By Gov't (Contract)			
01A4 B	By NFS	$565,000		

01A4C	By Gov't on behalf of NFS			
01A4D	Review of NFS		$56,500	
01A5	**Other Professional Services**	**$0**	**$0**	
01A5A	By the Gov't			
01A5B	By the NFS			
01A5C	By Gov't on behzlf of NFS			
01A5D	Review of NFS			
01A6	**Closing Cost (4% of Land Payments-01C1)**	**$21,000**	**$0**	
01A6A	By Gov't			
01A6B	By NFS	$21,000		
01A6C	By Gov't on behalf of NFS			
01A7	**PL 91-646 Assistance**	**$50,000**	**$25,000**	
01A7A	By Government			
01A7B	By NFS	$50,000		
01A7C	By Gov't on behalf of NFS			
01A7D	Review of NFS		$25,000	
01A8	**Audit**	**$0**	**$191,648**	
01A8A	By Gov't		$191,648	
01A9B	By NFS			
01B	**REAL ESTATE ACQUISITION COSTS**	**$525,000**	**$0**	**$525,000**
01B1	**Land Payments**	**$525,000**	**$0**	
01B1A	By Government			
01B1B	By NFS	$525,000		
01B1C	By Gov't on behalf of NFS			
01B2	**Damage Payments**	**$0**	**$0**	
01B2A	By Government			

01C2B	By NFS			
01C2C	By Gov't on behalf of NFS			
01B3	**PL 91-646 Payment**	**$0**	**$0**	
01B3A	By Government			
01B3B	By NFS	$0		
01B3C	By Gov't on behalf of NFS			
01B4	**Condemnation**	**$0**	**$0**	
01B4A	By NFS	$0		
01B5	**Facility / Utility Relocations**	**$0**	**$0**	
01B5A	By NFS			
01B6	**Disposals**	**$0**	**$0**	
01B6A	By Government			
01B6B	By NFS			
01B6C	By Gov't on behalf of NFS			
01C	**LERRD CREDITING**		**$1,039,200**	

TOTAL PROJECT REAL ESTATE COSTS (Cost-Shared 50%-50%)		**Non-Federal**	**Federal**	**Project Cost**
ROBINSON'S BRANCH NON-STRUCTURAL 10 YEAR				
	Cost Summary:			
	Incidental Costs (01A)	$292,700	$111,866	$404,566
	Real Estate Acquisition Costs (01B)	$0	$0	$0
	Subtotal:	$292,700	$111,866	$404,566
	20% Contingency	$58,540	$22,373	$80,913
01	**LANDS AND DAMAGES**	$351,240	$134,239	**$485,479**

01A	**INCIDENTAL COSTS**	**$292,700**	**$111,866**	**$404,566**
01A1	**Acquisition (Admin Costs)**	**$150,000**	**$75,000**	
01A1A	By Government (Gov't)		$75,000	
01A1B	By Non-Federal Sponsor (NFS)	$150,000		
01A1C	By Gov't on behalf of NFS			
01A2	**Survey**	**$10,500**	**$1,250**	
01A2A	By Gov't (In-house)			
01A2B	By Gov't (Contract)			
01A2C	By NFS	$10,500		
01A2D	By Gov't on behalf of NFS			
01A2E	Review of NFS		$1,250	
01A3	**Appraisal**	**$0**	**$0**	
01A3A	By Gov't (In-house)			
01A3B	By Gov't (Contract)			
01A3C	By NFS	$0		
01A3D	By Gov't on behalf of NFS			
01A3E	Review of NFS		$0	
01A4	**Title Services**	**$0**	**$0**	
01A4A	By Gov't (Contract)			
01A4B	By NFS	$0		
01A4C	By Gov't on behalf of NFS			
01A4D	Review of NFS		$0	
01A5	**Other Professional Services**	**$25,200**	**$12,600**	
01A5A	By the Gov't			
01A5B	By the NFS	$25,200		
01A5C	By Gov't on behzlf of NFS			
01A5D	Review of NFS		$12,600	
01A6	**Closing Cost (4% of Land Payments-01C1)**	**$0**	**$0**	
01A6A	By Gov't			
01A6B	By NFS	$0		
01A6C	By Gov't on behalf of NFS			
01A7	**PL 91-646 Assistance**	**$107,000**	**$0**	
01A7A	By Government			

01A7B	By NFS	$107,000		
01A7C	By Gov't on behalf of NFS			
01A7D	Review of NFS		$0	
01A8	**Audit**	**$0**	**$35,616**	
01A8A	By Gov't		$35,616	
01A9B	By NFS			
01B	**REAL ESTATE ACQUISITION COSTS**	**$0**	**$0**	**$0**
01B1	**Land Payments**	**$0**	**$0**	
01B1A	By Government			
01B1B	By NFS	$0		
01B1C	By Gov't on behalf of NFS			
01B2	**Damage Payments**	**$0**	**$0**	
01B2A	By Government			
01C2B	By NFS			
01C2C	By Gov't on behalf of NFS			
01B3	**PL 91-646 Payment**	**$0**	**$0**	
01B3A	By Government			
01B3B	By NFS	$0		
01B3C	By Gov't on behalf of NFS			
01B4	**Condemnation**	**$0**	**$0**	
01B4A	By NFS	$0		
01B5	**Facility / Utility Relocations**	**$0**	**$0**	
01B5A	By NFS			
01B6	**Disposals**	**$0**	**$0**	
01B6A	By Government			
01B6B	By NFS			
01B6C	By Gov't on behalf of NFS			
01C	**LERRD CREDITING**		**$175,620**	

EXHIBIT "E"

NON-FEDERAL SPONSOR CAPABILITY ASSESSMENT CHECKLIST

ASSESSMENT OF NON-FEDERAL PROJECT PARTNERS'S REAL ESTATE ACQUISITION CAPABILITY

RAHWAY RIVER BASIN, NEW JERSEY FLOOD RISK MANAGEMENT FEASIBILITY STUDY

I. <u>Legal Authority.</u>

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? Yes.

b. Does the sponsor have the power of eminent domain for this project? Yes.

c. Does the sponsor have "quick-take" authority for this project? Yes.

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No.

II. <u>Human Resource Requirements.</u>

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? No.

b. If the answer to II.a is "yes," has a reasonable plan been developed to provide such training?

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes.

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? Yes.

e. Can the sponsor obtain contractor support, if required in a timely fashion? Yes.

f. Will the sponsor likely request USACE assistance in acquiring real estate? No.

III. <u>Other Project Variables.</u>

a. Will the sponsor's staff be located within reasonable proximity to the project site? Yes.

b. Has the sponsor approved the project/real estate schedule/milestones? Yes.

IV. <u>Overall Assessment</u>.

a. Has the sponsor performed satisfactorily on other USACE projects? Yes.

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. If sponsor is believed to be "insufficiently capable," provide explanation. Highly Capable.

V. <u>Coordination.</u>

a. Has this assessment been coordinated with the sponsor? Yes.

b. Does the sponsor concur with this assessment? Sponsor has not responded to this form.

Reviewed and approved by:

____

Noreen Dean Dresser
Chief of Real Estate Division
Real Estate Contracting Officer
New York District Corps of Engineers

Draft Appendix F

Project Area Photographs

Rahway River Basin, New Jersey
Flood Risk Management Feasibility Study

November 2016

New Jersey
Department of
Environmental Protection

U.S. Army Corps of Engineers
New York District

Photo: View of North End of Orange Reservoir Looking Northeast

Photo 2: View of Orange Reservoir Dam Looking East.

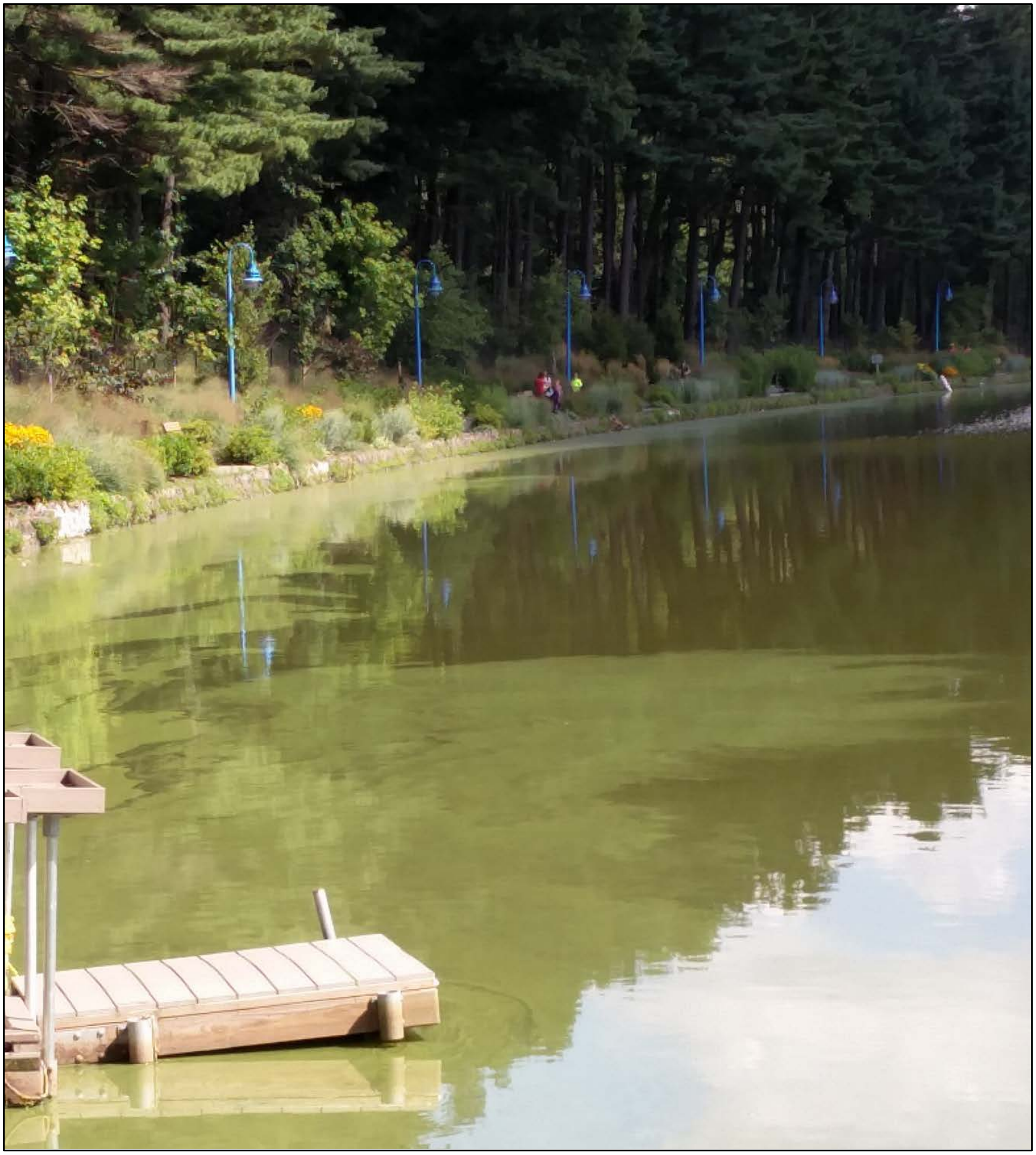

Photo 3: Orange Reservoir Looking West from Dam

Photo 4: Orange Reservoir Dam Spillway

Photo 5: Rahway River below Orange Reservoir Dam

Photo 6: Rahway River Looking South from the Nomahegan Park Footbridge, Township of Cranford

Photo 7: Right Bank of Rahway River Across from Normandie Place and Riverside Drive, Township of Cranford

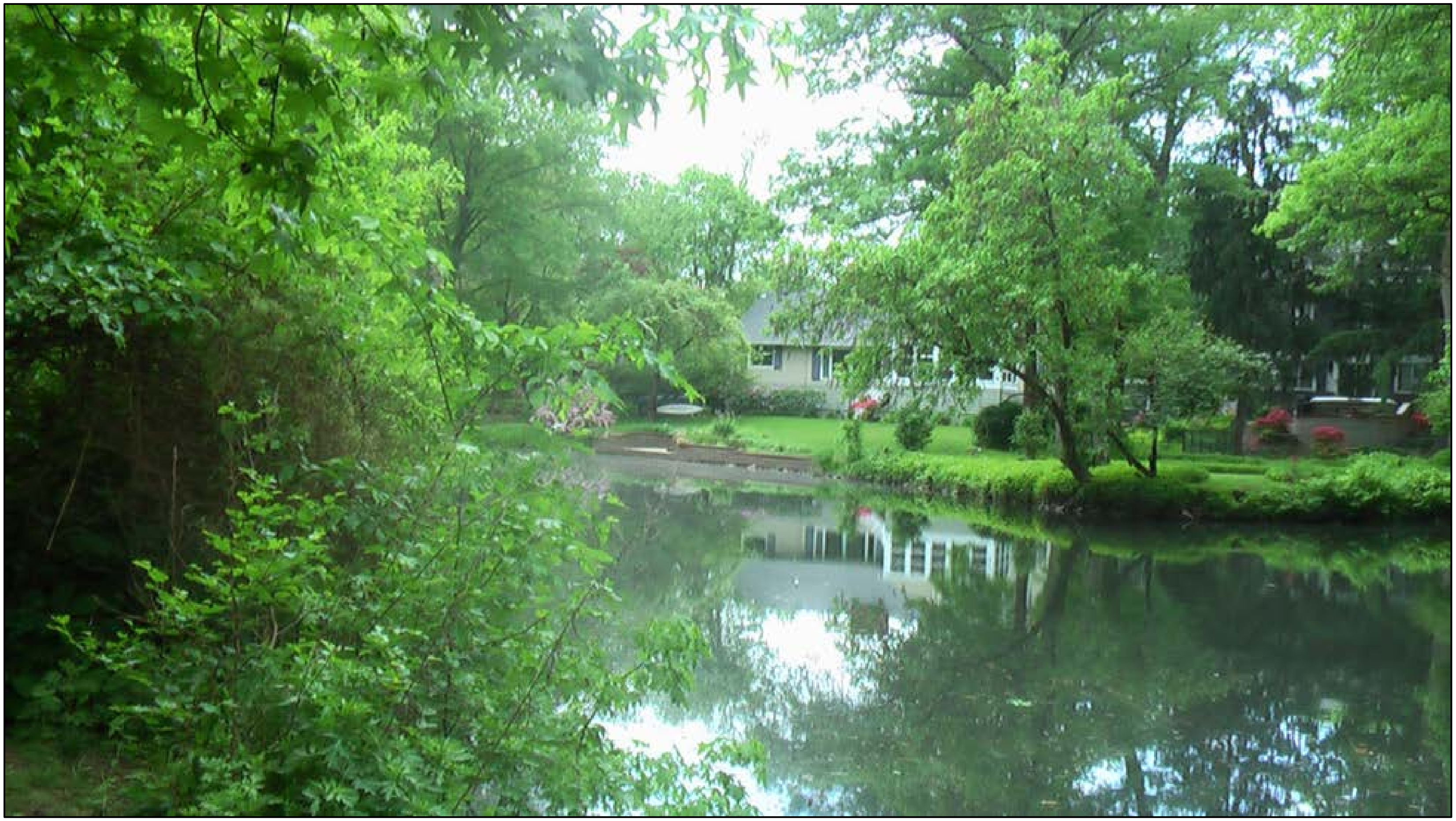

Photo 8: View of Rahway River from McConnell Park, Township of Cranford

Photo 9: Hansel Dam at Sperry Park, Township of Cranford

Photo 10: Right Bank of Rahway River North of Hansel Dam, Township of Cranford

Photo 11: Left bank of Rahway River Across from Hanson Park, Township of Cranford.

Photo 12: View of Robinson's Branch Upstream of Maple Avenue Bridge

Photo 13: View of Robinson's Branch Upstream of St. Georges Avenue Bridge

Photo 14: View of Robinson's Branch Upstream of Hamilton Street Bridge

Photo 15: View of Robinson's Branch Upstream of Irving Street Bridge